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Annual and decadal change in Atlantic salmon (*Salmo salar*) abundance in eastern Canada

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Abstract

The data series of returns and at-sea survivals of Atlantic salmon to monitored rivers in eastern Canada are used to address three issues: 1) whether returns and sea survivals in 1997 were unusual, 2) whether there were spatial and or temporal correlations in the returns and sea survivals, and 3) whether there are spatial patterns in the returns trends in the last decade. The survival rates to 1SW salmon and 2SW salmon observed for the 1997 returns were among the lowest observed in the recent 5-year and 10-year time periods. There was a broad scale pattern of decline from the previous year in survival rates of 1SW and 2SW salmon across the monitored rivers of eastern Canada in 1997. The probability of such a broad scale decline by chance alone was less than 4%. There was a broad spatial scale decline in the small salmon returns to eastern Canada in 1997 relative to 1996 with declines observed in over 80% of rivers. The trends in returns of small salmon and large salmon provide a geographically segregated picture of abundance patterns for four geographic areas of eastern Canada. Strong declines characterise the rivers of the Bay of Fundy and Atlantic coast of Nova Scotia. Rivers in Québec are characterised by declining or relatively stable abundance. The southern Gulf of St. Lawrence rivers are defined by declining through stable through slight increased abundance. Finally, insular Newfoundland rivers are characterised by stable through increasing through strongly increasing abundance. The contrasts in the patterns of evolution of the returns over the last decade prevent the formulation of any general statement regarding an overall improvement or deterioration of Atlantic salmon status in eastern Canada.

Résumé

Les séries de données comprenant les retours et les taux de survies en mer du saumon Atlantique des rivières de l'est du Canada ont servi à répondre aux trois questions suivantes : 1) si les retours et taux de survies de 1997 étaient extraordinaires, 2) s'il y avait des corrélations temporelles ou géographiques dans les retours et taux de survies, et 3) s'il y avait des similarités géographiques dans les tendances temporelles des retours de la dernière décennie. Les taux de survies des saumons unibermarins (1SW) et dibermarins (2SW) en 1997 étaient parmi les plus faibles observés durant les 5 et 10 dernières années. Les diminutions en 1997 par rapport à 1996 ont été observées sur une grande échelle géographique à travers l'est du Canada. Il était improbable (<4%) que ce phénomène géographique ce soit manifesté purement au hasard. Un pareil phénomène de diminution a été observé pour les retours aux rivières des petits saumons dans l'est du Canada. Une diminution par rapport à 1996 s'est manifestée dans 80% des rivières. Les tendances temporelles des retours de petits et de grands saumons durant la dernière décennie se partagent géographiquement en quatre régions. Des fortes diminutions caractérisent les populations des rivières de la Baie de Fundy et de la côte Atlantique de la Nouvelle-Ecosse. Les populations des rivières du Québec sont caractérisées par des diminutions ou abondances stables. Dans le sud du Golfe du Saint-Laurent, les populations comprennent des diminutions, aucune tendance ou faible augmentation d'abondance. Enfin à Terre-Neuve, les tendances d'abondance sont stables jusqu'à forte croissance. Ces tendances opposées selon les régions géographiques durant la dernière décennie nuisent à une interprétation généralisée de l'état du saumon Atlantique dans l'est du Canada.

Introduction

The abundance of Atlantic salmon adults is extremely variable (Dempson et al. 1998). Factors accounting for this variability include variations in sea mortality (fisheries and natural) and variations in recruitment (juvenile production). When fish abundance is measured after fisheries, variations in fishery exploitation may augment the variability in the measured component of the fish population. When ocean fisheries are closed, there is an obvious expectation and frequent realisation of increased numbers of fish in the rivers (Dempson et al. 1998, Moore et al. 1995). But lower returns of fish are also observed. The causes of fluctuations in fish abundance can be numerous and frequently no single cause may dominate. The important questions to be addressed in cases of lower or higher than expected abundance are whether the observed values are truly unexpected (given previously observed annual variations) and of broad geographical scale.

Smolt counts and returns of adult salmon in the subsequent year(s) provide direct measures of at-sea survival. Generally, adult returns are to the river such that the calculated survival rate accounts for both fishing (F) and natural mortality (M). Annual variations in at-sea survival would be determined by variations in both F and M; in some cases the variation would be in the same direction, in other years in opposite directions.

The linkage of variations in abundance to sea survival are indirect for time series involving only adult estimates because the freshwater production (recruitment to the ocean) is unmeasured. Annual variability in returns therefore would be a factor of not only variability in natural and fisheries mortality rates at sea but also variability in smolt production. With such series, it is more difficult to discern anomalous changes in sea survival and to assess the spatial-based correlations of marine phenomena. But there are many more monitored rivers with adult returns and it is this large amount of data which provides the best opportunity to assess the spatial phenomenon of the relative changes in sea survival.

Adult returns are also an essential element for assessing stock status. An analysis of trends in returns over time provides insight into the evolution of abundance and for situating annual events, like the perceived low abundance of 1997, in a broader context.

In this paper, we use the database of returns and at-sea survivals from monitored rivers in eastern Canada to address the following questions:

- Were the returns and sea survivals in 1997 unusual?
- Are there spatial and or temporal correlations in the returns and sea survivals of Atlantic salmon to eastern Canada?
- Are there spatial patterns in the trends of returns to rivers in eastern Canada in the last decade?

MATERIALS AND METHODS

Data sets used include the sea survival time series from eastern Canada and the returns estimates by size groups (Appendices 1 to 4).

Some of the factors associated with natural sea survival, such as environmental conditions, tend to be autocorrelated such that generally, dramatic changes in relative survival rates from year to year are infrequently observed. Relative change from the previous year (i.e. $Year_{i+1}$ / $Year_i$) is a measure of the temporal variability of survival rates within a river and among rivers. This index is of interest since we would expect any relative change in environmental conditions which affect natural mortality or relative change in fishing mortality to be proportional rather than absolute. The use of a relative change index also removes the trend in the time series of observations and provides a common scale for comparing among rivers.

Spatial and temporal correlations were examined using an index of relative change:

$$\text{Ln}(\text{Measure}_{i+1,j} / \text{Measure}_{i,j})$$

where Measure = survival rate, or abundance (count or return at index facility)
i = year, and
j = river or index facility.

Measures within the same year were assessed for the likelihood of a spatial scale association of sea survivals or returns. When a broad scale phenomenon affecting sea survival occurs, the relative changes from the previous year are expected to be of a similar sign in a large number of rivers. Under the null hypothesis, the relative change would be a purely random process among rivers with the probability of either negative or positive change equal to 0.5. The power of this binomial likelihood description to correctly capture a global event when it is present (i.e. $1-\beta$ represents the probability of rejecting H_o when it is false) was assessed by Monte Carlo method. Smolt production and returns to 25 rivers were generated assuming F and M at sea were approximately distributed as $N(\mu, \sigma^2)$ and serial correlation = 0. In the case of a global event affecting a group of rivers, F and M varied according to a common random deviate but with annual smolt production from individual rivers varying independently (otherwise the pattern of returns to the rivers would be identical). The power of the binomial likelihood test was determined for two α levels of rejection, 0.05 and 0.01 and for sample sizes of 10 and 25 rivers. A total of 2000 simulations were performed for each test.

The power of the binomial test was very high for spatial correlation of changes in survival rates at both levels of significance and for small (10 rivers) or large (25 rivers) data sets of rivers (Table 1). For changes in returns to rivers, the test was not as strong, especially for the data set with 10 rivers and at $\alpha <= 0.01$ where the null hypothesis was correctly rejected about half the time (Table 1). A data set of at least 25 rivers would be required to assess with some confidence the presence of a broad scale phenomenon affecting returns to rivers in eastern Canada.

The magnitude of the changes relative to previous time periods was also used to determine the peculiarity of 1997. We also determined if a positive response in abundance was observed after the imposition of the 1992 commercial fisheries moratoria. A t-test comparing the average relative change between two periods was used with the significance of the test statistic determined by randomization (N=1000) as described in Manly (1991).

Grouping of rivers according to the temporal trends in returns of wild salmon were discerned using cluster analysis. Wild salmon refers to fish which were considered to have been spawned and reared in the river. The data used represent returns to the rivers and are not representative of total population size for all rivers since no adjustments were made for commercial exploitation. A total of 38 rivers were included in the analyses and with few exceptions, the time series was complete for at least 10 of the 11 years between 1987 and 1997 (Appendix 2). One river had no data for small salmon (North River, Nova Scotia) and one had no data for large salmon (Humber River, Newfoundland). The individual river mean was substituted when there was a missing annual value for an individual river. The returns were divided into size groups: (small salmon are fish less than 63 cm fork length, large salmon are fish greater than or equal to 63 cm fork length). The two sets of series, for small and large salmon, were analysed separately. Each river time series was adjusted by dividing by its corresponding mean (1987 to 1997). This produced a standard scale across rivers of different run sizes (i.e. the average of each river time series is equal to 1) but maintained differences between river time series regarding their variability.

The time series were first processed through correspondence analysis before being subjected to cluster analysis. The first five factors from the correspondence analysis were retained and used in the cluster analysis of the rivers. The factors of higher order were discarded because they were poorly informative (i.e. representing "white noise"). The cluster analysis was carried out following the Ascending Hierarchical Classification (AHC) technique, based on an inertia criterion using the Chi-square distance and by means of the reciprocal-neighbours algorithm (Lebart et al. 1984). Several groups of the set of river-time series were deduced from the classification tree built by the AHC. Each partition is made of different river-time series

that exhibit a common pattern of abundance over time within each class with contrasted patterns among classes.

RESULTS

Characterisation of at-sea survival rates

Survival rates of smolts to 1SW salmon in 1997 were down from the previous year in most of the rivers (Table 2). Survival rates to 2SW salmon were down or similar to previous year's indicating that the effect of reduced survival was greater on the smolt migration of 1996 than of 1995. The survival rates to 1SW salmon and 2SW salmon observed for the 1997 returns were among the lowest observed in the recent 5-year and 10-year time periods in most of the monitored rivers; the most common temporal rank of the 1997 returns for individual rivers being the lowest or second lowest in the respective time periods (Table 2).

There was a broad scale pattern of change in survival rates of 1SW salmon across the monitored rivers of eastern Canada in 1997. Survival rates in 1997 declined relative to 1996 in 9 of 11 monitored rivers and the likelihood of observing such a pattern under the null hypothesis of independence was 0.033 (Fig. 1). The spatial pattern of survivals in 1996 relative to those of 1995 were also unlikely ($P = 0.011$) under the assumption of independence; in 1996, smolt survivals improved in 11 of the 13 monitored rivers. The survivals to 2SW maiden salmon in 1997 were also spatially correlated. Declines in 1997 relative to 1996 were observed in 7 of 8 rivers and the probability of such an event under the assumption of independence was 0.035 (Fig. 2). The only other year with spatially correlated changes in survivals was the 1994 returns of 2SW salmon (1992 smolt migration) where declines from the previous year were observed in 7 of the 8 rivers ($P = 0.035$).

For the 1984 to 1990 smolt migrations, the relative change in survival rates for the Newfoundland rivers tended to be negative whereas the median level for the mainland stocks was near zero (Table 3, Fig. 3). After the imposition of the commercial fisheries moratoria in Newfoundland in 1992, annual survival rates to the river in the Newfoundland stocks improved while the mainland stock survival rates showed little change (Table 3). The relative change in survival rates for the 1991 smolt migration (1SW returns of 1992) relative to the previous year was expected to be positive for the Newfoundland rivers as an immediate result of the additional fish not harvested in coastal fisheries. But the relative survival rates were unchanged and comparable to those observed in the previous seven years (Table 3, Fig. 3). Relative changes in survival rates to 1SW salmon of the 1996 smolts (1SW adult returns of 1997) from the Newfoundland rivers and for all rivers monitored in eastern Canada were significantly lower than those observed in the previous four years during the commercial fishing moratoria (Table 3, Fig. 3).

Change in survival rates to 2SW salmon were similar between the two management periods (Fig. 4). Change in survival rates of the 1990 smolt migration (1992 returns as 2SW salmon) and the 1995 smolt migration (1997 returns of 2SW salmon) were within the variation in relative changes observed in the two preceding time periods (Table 3, Fig. 4).

Characterisation of returns

Returns of Atlantic salmon in 1997 were down relative to 1996 in the majority of rivers of eastern Canada: 82% of rivers for small salmon, 58% of rivers for large salmon and 79% of rivers for both sizes combined (Table 4). Returns of small salmon and large salmon were particularly reduced in mainland Canada rivers (86% and 78% for small and large respectively). In Newfoundland, small salmon declines were observed in most rivers (73%) while large salmon returns were similar or increased in 73% of the monitored rivers (Table 4). Large salmon in Newfoundland rivers are predominantly repeat spawning 1SW salmon whereas in mainland Canada rivers (most), large salmon are comprised of maiden 2SW and 3SW salmon and varying proportions of repeat spawning 1SW and 2SW maiden origin fish.

Relative to the previous five and ten years, returns in 1997 were among the lowest observed in each time period (Table 5). This was particularly so for the mainland rivers for both small salmon and large salmon size groups. For Newfoundland, returns of small salmon in 1997 were among the lowest observed since the commercial moratoria of 1992 and were generally in the mid-range of returns observed since 1987 (Table 5). For large salmon, returns to Newfoundland rivers in 1997 were among the highest of the last 5-year and 10-year time periods.

Returns of small and large salmon

There were broad spatial scale patterns of change in the small salmon returns to eastern Canada in 1996 and 1997 (Fig. 5). Returns in 1996 were improved from 1995 in 70% of the monitored rivers in eastern Canada whereas decreases in returns from 1996 were observed in over 80% of rivers in 1997. These changes were unlikely to have been observed by chance under the null hypothesis of independence among rivers. Significant changes from the previous year were also noted in 1986, 1989, 1991, and 1992 (Fig. 5). In contrast, there were no apparent spatial scale associations in returns of large salmon to eastern Canadian rivers with the possible exception of 1986 (Fig. 5). There were regional differences between mainland Canada and insular Newfoundland. For the mainland rivers, there were significant ($P<0.001$) declines in small salmon returns from the previous year in 1991, 1993 and 1997 while significant increases were noted in 1986 (Fig. 6). The evidence is weaker of a common phenomenon affecting the relative changes in abundance of large salmon in mainland river stocks; weak associations were noted for the 1986, 1993 and 1997 returns (Fig. 6).

For the Newfoundland stocks, the returns of small salmon and large salmon in 1992 increased from 1991 in 13 of the 14 monitored rivers (Fig. 7). The obvious common phenomenon affecting the Newfoundland returns to rivers during 1991/1992 interval was the introduction of the commercial salmon moratorium in 1992. Since 1992, small salmon returns have increased or decreased from the previous year seemingly independently among rivers. In the majority of rivers since 1992, large salmon returns have been increasing from the previous year but the inter-river variability was sufficiently large that independence among the Newfoundland rivers could not be discounted. Relative change in returns in 1997 from 1996 for Newfoundland stocks was not indicative of a broad scale phenomenon.

Between 1985 and 1991 (mainland commercial fisheries closed, Newfoundland commercial fisheries open), small salmon returns to rivers in Newfoundland generally declined whereas in mainland rivers, the relative changes in returns were positive (Table 6, Fig. 8). Since 1993 (commercial fisheries in mainland Canada and Newfoundland closed), relative change in mainland rivers has been negative whereas for Newfoundland rivers, there was a general increase in returns. These area differences in both management time periods were significant (Table 6). The 1992 commercial moratoria resulted in a significantly large increase in small salmon returns in Newfoundland rivers but was not generally detectable in the mainland rivers (Table 6, Fig. 8). The 1997 returns in both Newfoundland and mainland rivers were a significantly greater decline from 1996 than the variability in the relative changes observed during the 1993 to 1996 time period (Table 6, Fig. 8).

Interannual changes in large salmon abundance were significantly positive since the 1992 moratorium in Newfoundland but not in mainland rivers (Table 6, Fig. 9). As with the small salmon, there were opposing patterns of change in the two geographic areas during the 1980's management period relative to the 1990's (Table 6). In 1992, large salmon returns increased relative to 1991 in the Newfoundland rivers but no increase was observed in the mainland rives. The change in large salmon from 1996 to 1997 was significantly negative in the mainland rivers but no change was evident in the Newfoundland rivers. For most Newfoundland rivers, the large salmon are predominantly repeat spawners while in mainland rivers, a large proportion of the large salmon are maiden 2SW and 3SW salmon.

Temporal and Spatial Patterns of Abundance

Cluster analysis of 37 rivers of eastern Canada according to their returns of small salmon and large salmon since 1987 provided clear patterns of abundance trends over time. Small salmon returns series were partitioned into six groups whereas five groups were distinguished for large salmon.

For small salmon, three major patterns (with two subpatterns each) emerged:

1. declining abundance since 1987 for eight rivers (Fig. 10) with:
    - a subgroup of three rivers with a strong initial decline followed by a levelling off at less than half the average return since 1993,
    - a second subgroup of five rivers with a less acute decline initially but continuing beyond 1993.
2. variable abundance around the average with a tendency to decline below the average over the last years for 16 rivers (Fig. 11) with:
    - a subgroup of six rivers with abundance above the average until 1993 and below average since 1994,
    - another subgroup of 10 rivers with almost no trend over time but variable abundance about the average and a tendency to pass slightly below the mean since 1995.
3. increasing abundance since 1987 for 12 rivers (Fig. 12) with:
    - a subgroup of four rivers with a gentle rising trend over the entire study period,
    - second subgroup of eight rivers with a two stage pattern, below average until 1991 and above average since 1993, the year 1992 being the turning point between the two levels.

For large salmon, two major patterns of abundance with subpatterns within were identified:

1. declining abundance since 1987 for 24 rivers (Fig. 13) with:
    - a subgroup of seven rivers showing a strong rate of decline in the first half of the study period and a stabilisation at low abundance in the second half,
    - a second subgroup of five rivers showing a weaker trend with a two stage pattern, above average abundance before 1992 and below average since 1993,
    - a third subgroup of 12 rivers fluctuating around the mean with essentially no trend even though a slight tendency to decline below the average seemed to appear during the last years,
2. increasing abundance over time in 12 rivers (Fig. 14) with:
    - a subgroup of six rivers with variable but slowly increasing returns, the abundance being generally below average until 1991 and above average since 1992,
    - a second subgroup of six rivers with strong increases in abundance, especially since 1992.

The trends in returns of small salmon and large salmon provide a geographically segregated picture of abundance patterns for four geographic areas of eastern Canada (Fig. 15):

1. Bay of Fundy and Atlantic coast of Nova Scotia characterised by a strong decline in abundance,
2. Québec rivers characterised by declining or relatively stable abundance,
3. Southern Gulf of St. Lawrence rivers with declining through stable abundance through slight increased abundance,
4. Insular Newfoundland with stable through increasing through strongly increasing abundance (with the exception of Conne River which had characteristics of the Bay of Fundy / Atlantic coast of Nova Scotia group).

DISCUSSION - CONCLUSIONS

The 1997 returns of small salmon declined relative to 1996 generally throughout eastern Canada. At-sea survival rates were generally lower in 1997 and among the lowest observed in the 5 and 10-year periods. There was evidence of a wide spatial-scale association in the relative change in returns of small salmon to eastern Canada. The widest ranging declines and the greatest proportional declines occurred in the mainland rivers. Large salmon declines were also widely distributed and greatest in the mainland rivers while the returns of large salmon to Newfoundland rivers actually improved in 1997 relative to 1996. The declines of small salmon in 1997 were most severe and occurred over a wider geographic range in the mainland rivers than in the Newfoundland rivers. There was evidence of a common phenomenon affecting the returns of small salmon to mainland rivers in 1997 but not so for the Newfoundland rivers. A similar conclusion was reach by Power (1998) using different analysis techniques.

Although the 1997 returns in eastern Canada were poor and generally substantially below expectations, the greatest concern relates to the trends in abundance of many stocks in the Bay of Fundy and Atlantic coast of Nova Scotia and in the south coast of Newfoundland. The continued decline since 1987 observed in a number of these rivers and the presently low abundance of salmon in these rivers are of particular concern. Causes of the decline can be clearly related to acidification problems for the rivers of the Atlantic coast of Nova Scotia (Watt 1997) but are not well understood for the Bay of Fundy rivers. Gulf of St. Lawrence and Québec rivers stocks have been essentially fluctuating about their mean over the last decade with a decline over the last years. These populations have probably been suffering reduced sea-survival over the last decade like most stocks in Canada (DFO 1997) but the higher overall abundance in these rivers provides sufficient stock recovery potential. Returns to rivers of small and large salmon are generally improved in Newfoundland since the 1992 commercial moratorium with the exception of some south coast populations. Now that commercial fisheries have been closed, returns to the rivers represent the total stock size which in many rivers could still remain lower than the fish returning to the rivers in the previous decades when large numbers of these were harvested and not accounted for in the in-river returns (Dempson et al. 1998). The contrasts in the patterns of trends in returns over the last decade prevent the formulation of any general statement regarding an overall improvement or deterioration of Atlantic salmon status in Canada. Nevertheless, a good synthetic view of the situation can be discerned by the examination of trends on a regional basis.

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Table 1. Results of the Monte Carlo simulations of the power of the binomial likelihood test to detect a global factor affecting the fishing and natural mortality rates on smolts returning as adults.

Relative change from previous year in returns to rivers (does not account for smolt production		
	Power (1-β)	
Number of rivers examined	at α <= 0.05	at α <= 0.01
10	0.662	0.502
25	0.838	0.805

Relative change from previous year in survival rate (measured as returns to the river)		
	Power (1-β)	
Number of rivers examined	at α <= 0.05	at α <= 0.01
10	0.961	0.944
25	0.992	0.985

Table 2. Trends in survival rates of smolts to 1SW and 2SW maiden salmon to rivers of eastern Canada.

Relative to previous year		Number of rivers		
		Decline (<-10%)	Same	Increase (>10%)
1SW	Hatchery	3		1
	Wild	6		1
2SW	Hatchery	2	1	1
	Wild	2	2	

Rank of 1996 smolt (for 1SW) and 1995 smolt (for 2SW) survivals for individual rivers within the time period						
		Best	Worst	Median	Mode	N
Previous five year						
1SW	Hatchery	2	6	5	6	4
	Wild	4	6	5	5	5
	Both	2	6	5	6	9
2SW	Hatchery	5	6	5	5	3
	Wild	4	5	5	5	3
	Both	4	6	5	5	6
Previous ten year						
1SW	Hatchery	8	11	8.5	8	4
	Wild	7	10	10	10	3
	Both	7	11	9	8	7
2SW	Hatchery	8	10	10	10	3
	Wild			10		1
	Both	8	10	10	10	4

Table 3. Change in survival rates in different management periods and in 1997 of smolt to 1SW and 2SW maiden salmon. The years are expressed as the year of smolt migration.

Comparing management periods	Median	N	Median	N	P-value
Survival rates of smolts to 1SW					
	84-90		92-95		
Eastern Canada	0.000	(43)	0.092	(50)	0.82
Mainland	0.030	(29)	-0.048	(30)	0.54
Newfoundland	-0.086	(14)	0.148	(20)	**0.036**
	84-90		1991		
Eastern Canada	0.000	(43)	-0.224	(11)	0.68
Mainland	0.030	(29)	-0.315	(7)	0.61
Newfoundland	-0.086	(14)	-0.017	(4)	0.86
	92-95		1996		
Eastern Canada	0.092	(50)	-0.763	(11)	**0.011**
Mainland	-0.048	(30)	-0.718	(6)	0.215
Newfoundland	0.148	(20)	-0.839	(5)	**0.003**
Survival rates of smolts to 2SW salmon (mainland Canada only)					
	83-89		1990		
	-0.070	(27)	-0.071	(6)	0.64
	90-94		1995		
	-0.047	(24)	0.078	(7)	0.85

Table 4. Change [(97-96)/96] in returns to rivers of small salmon, large salmon and both size groups combined.

		Small	Large	Both
Eastern Canada	Total rivers	50	50	52
	Decline (< 10%)	41	29	41
	Increase (> 10%)	6	13	6
	No change	3	8	5
Mainland Canada	Total rivers	35	35	37
	Decline (<-10%)	30	25	30
	Increase (>10%)	3	6	3
	No change in 1997	2	4	4
Newfoundland	Total rivers	15	15	15
	Decline (<-10%)	11	4	11
	Increase (>10%)	3	7	3
	No change	1	4	1

Table 5. Rank of returns in 1997 by size group to rivers of eastern Canada relative to the previous five-year period and the previous ten-year period. A best rank of 1 means return in 1997 was highest in the time period examined. A worst rank of 6 in the five-year period or 11 in the ten-year period means return in 1997 was the lowest observed in the corresponding time period. The median is the rank for 1997 for which half the rivers in the comparison were above and half were below. The mode rank is the most common rank for the 1997 returns for all the rivers examined. N is the number of rivers considered.

	Best	Worst	Median	Mode	N
Relative to 1992 to 1996 (5-year)					
Small salmon					
Eastern Canada	1	6	5	6	38
Mainland	2	6	5.5	6	26
Newfoundland	1	6	4.5	6	12
Large salmon					
Eastern Canada	1	6	5	6	40
Mainland	1	6	6	6	28
Newfoundland	1	6	1	1	12
Small and large combined					
Eastern Canada	1	6	5	6	43
Mainland	1	6	6	6	31
Newfoundland	1	6	4	5	12
Relative to 1987 to 1996 (10-year)					
Small salmon					
Eastern Canada	1	11	9	10	30
Mainland	3	11	10	10, 11	21
Newfoundland	1	10	5	5, 7	9
Large salmon					
Eastern Canada	1	11	10	11	31
Mainland	2	11	10	11	22
Newfoundland	1	10	1	1	9
Small and large combined					
Eastern Canada	1	11	9	11	35
Mainland	4	11	10	11	26
Newfoundland	1	10	5	4	9

Table 6. Change in returns by size group and geographic area of Atlantic salmon within two management periods (1985 to 1991, 1993 to 1996) and during 1992 and 1997.

		Median	N	Median	N	P-value
Small salmon						
		1985 to 1991		1993 to 1996		
Mainland Canada		0.012	(171)	-0.090	(128)	0.075
Newfoundland		-0.087	(83)	0.146	(73)	**0.002**
	P-value	**0.036**		**0.014**		
		1985 to 1991		1992		
Mainland Canada		0.012	(171)	0.234	(26)	0.124
Newfoundland		-0.087	(83)	0.733	(14)	**<0.001**
	P-value			**0.074**		
		1993 to 1996		1997		
Mainland Canada		-0.090	(128)	-0.540	(34)	**<0.001**
Newfoundland		0.146	(73)	-0.378	(15)	**0.002**
	P-value			0.150		
Large salmon						
		1985 to 1991		1993 to 1996		
Mainland Canada		0.020	(178)	-0.068	(129)	0.116
Newfoundland		-0.136	(75)	0.168	(73)	**0.004**
	P-value	**0.019**		**0.004**		
		1985 to 1991		1992		
Mainland Canada		0.020	(178)	-0.023	(27)	0.472
Newfoundland		-0.136	(75)	1.138	(14)	**<0.001**
	P-value			**<0.001**		
		1993 to 1996		1997		
Mainland Canada		-0.068	(129)	-0.314	(34)	**0.005**
Newfoundland		0.168	(73)	0.095	(15)	0.376
	P-value			**0.020**		

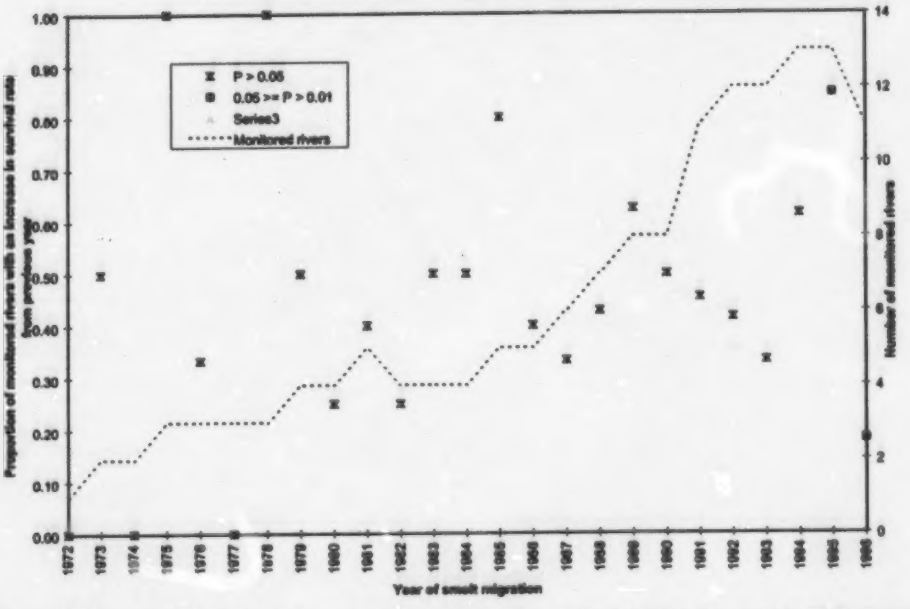


Figure 1. Proportion of rivers with an increase relative to the previous year in the smolt to 1SW survival rate in monitored rivers of eastern Canada. Includes both wild and hatchery origin smolts.

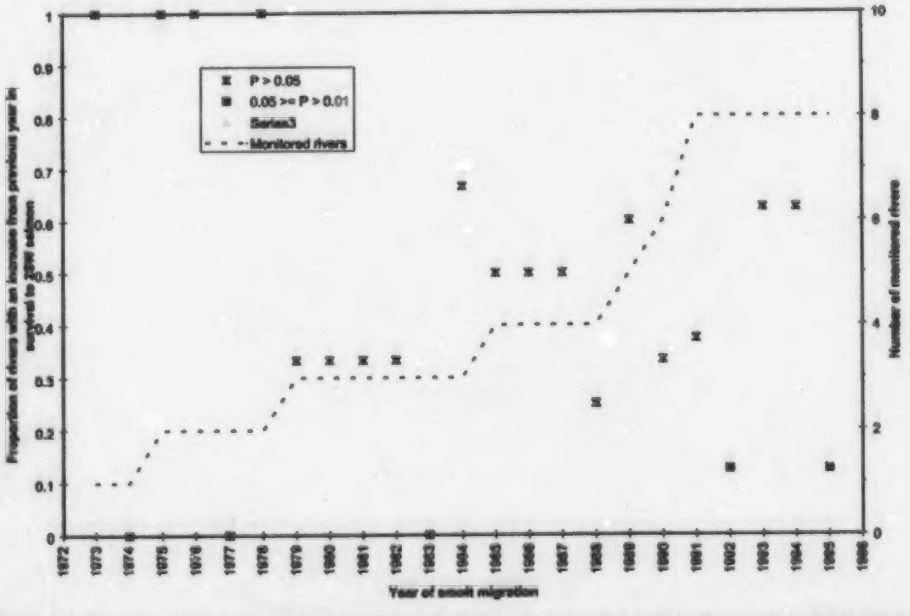


Figure 2. Proportion of rivers with an increase relative to the previous year in the smolt to 2SW survival rate in monitored rivers of eastern Canada. Includes both wild and hatchery origin smolts.

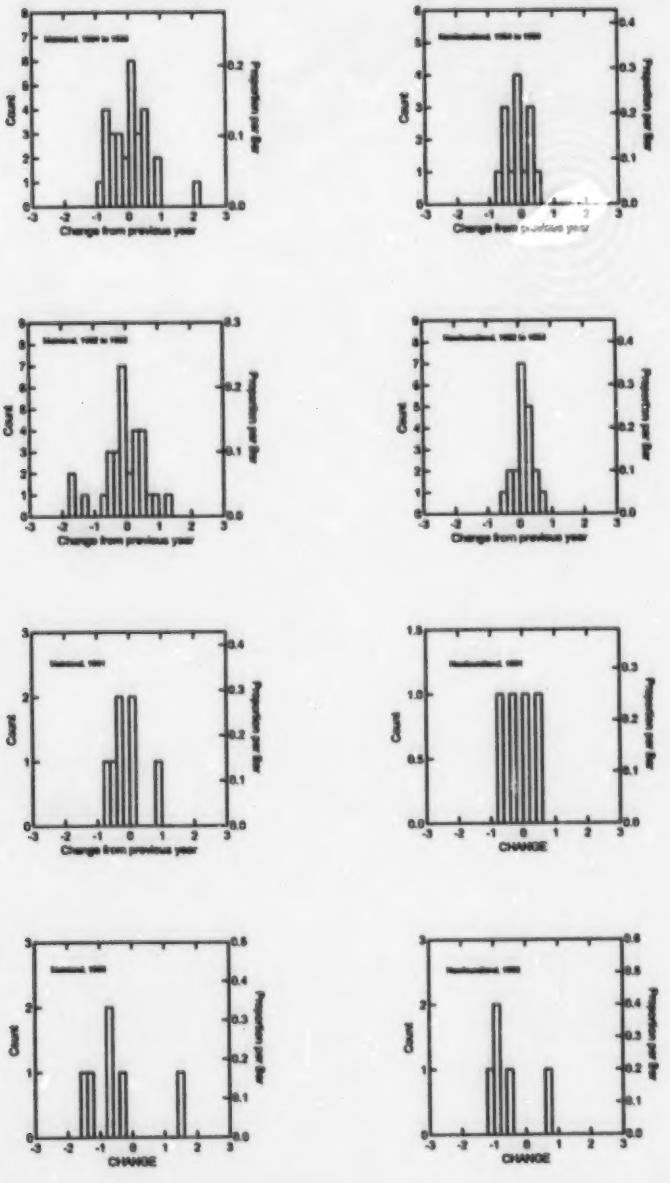


Figure 3. Change in survival rate (ln [surv year i+1 / surv year i]) of smolts to 1SW salmon returning to the monitored rivers of eastern Canada during two management regimes (1984 to 1990 - mainland Canada commercial moratorium and 1992 to 1995 - Newfoundland commercial moratorium) and 1991 and 1996 smolt migrations..

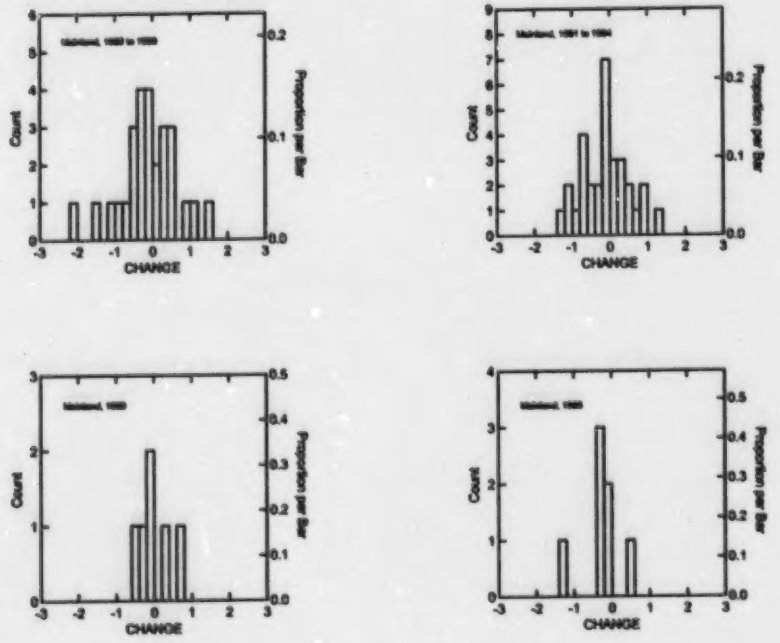


Figure 4. Change in survival rate (ln [surv year i+1 / surv year i]) of smolts to 2SW salmon returning to the monitored rviers of mainland Canada during two management regimes (1983 to 1989 - mainland Canada commercial moratorium and 1991 to 1994 - Newfoundland commercial moratorium). Also shown are the relative changes for the 1990 smolt migration (the 1992 returns) and the 1995 smolt migration (the 1997 returns).

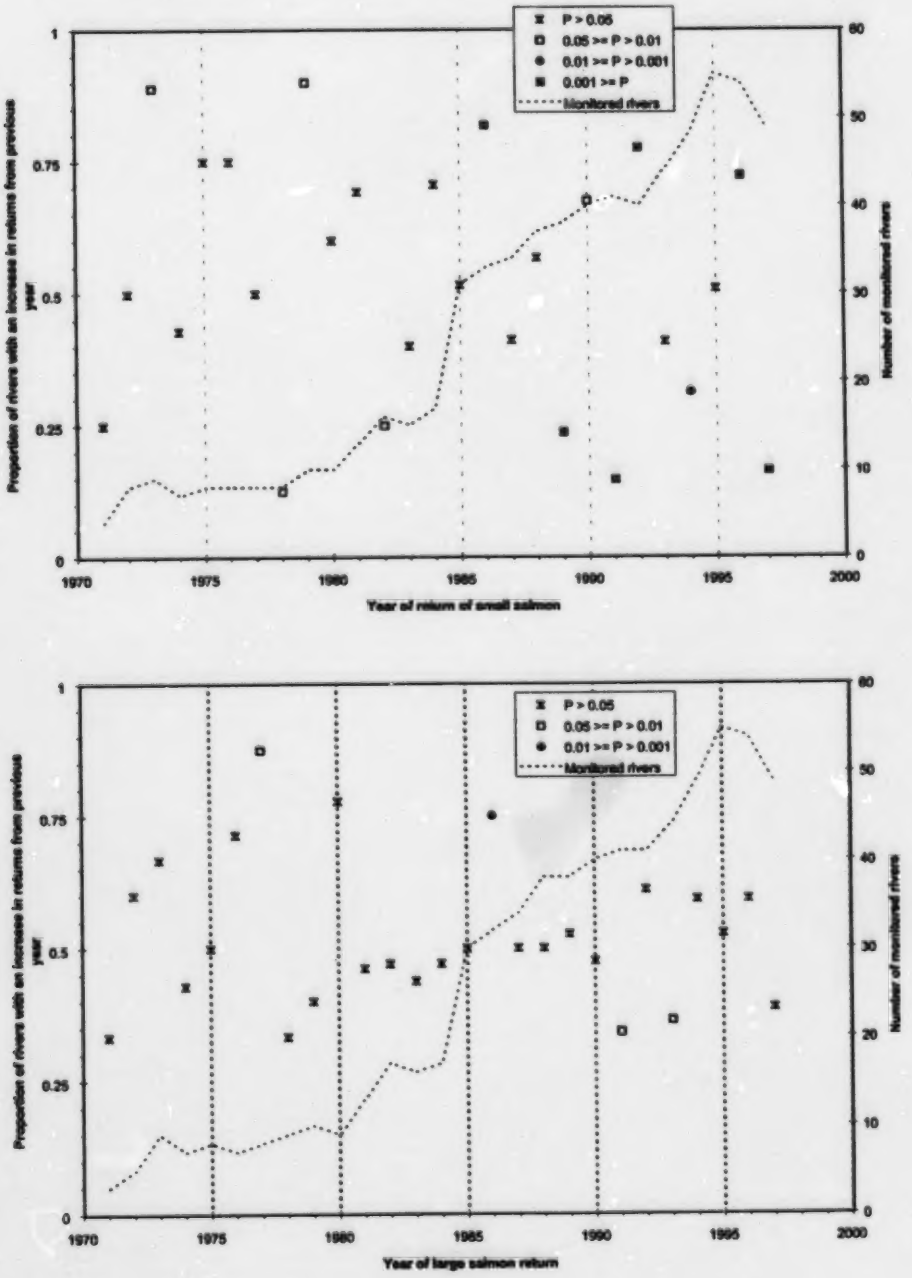


Figure 5. Proportion of rivers with an increase relative to previous year in the wild small salmon (upper panel) and wild large salmon (lower panel) returns to monitored rivers of eastern Canada.

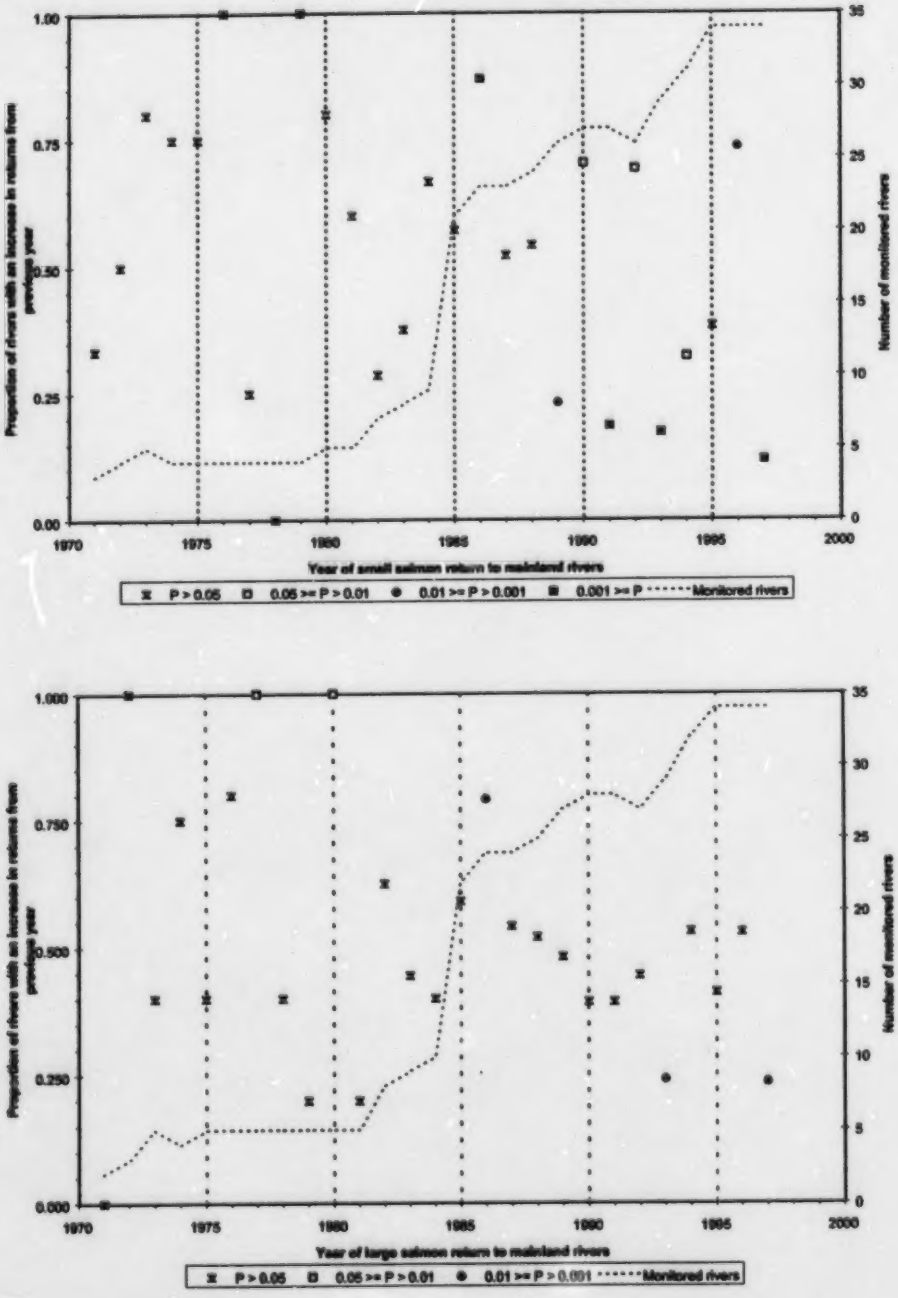


Figure 6. Proportion of rivers with an increase relative to previous year in the wild small salmon (upper panel) and wild large salmon (lower panel) returns to monitored rivers of mainland Canada.

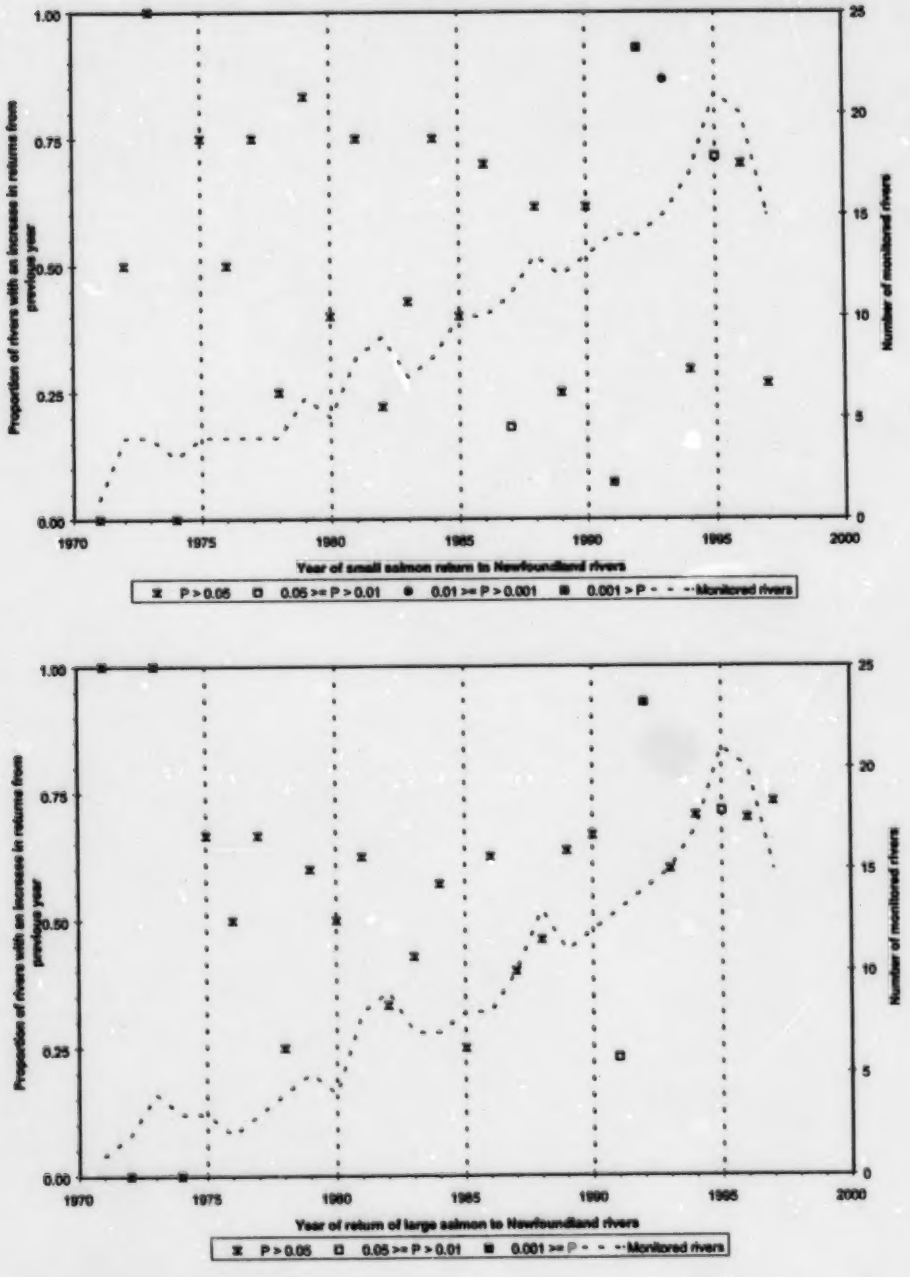

Proportion of rivers with an increase in returns from previous year
Number of monitored rivers
Year of small salmon return to Newfoundland rivers
P > 0.05
0.05 >= P > 0.01
0.01 >= P > 0.001
0.001 > P
Monitored rivers
Proportion of rivers with an increase in returns from previous year
Number of monitored rivers
Year of return of large salmon to Newfoundland rivers
P > 0.05
0.05 >= P > 0.01
0.001 >= P
Monitored rivers

Figure 7. Proportion of rivers with an increase relative to previous year in the wild small salmon (upper panel) and wild large salmon (lower panel) returns to monitored rivers of Newfoundland.

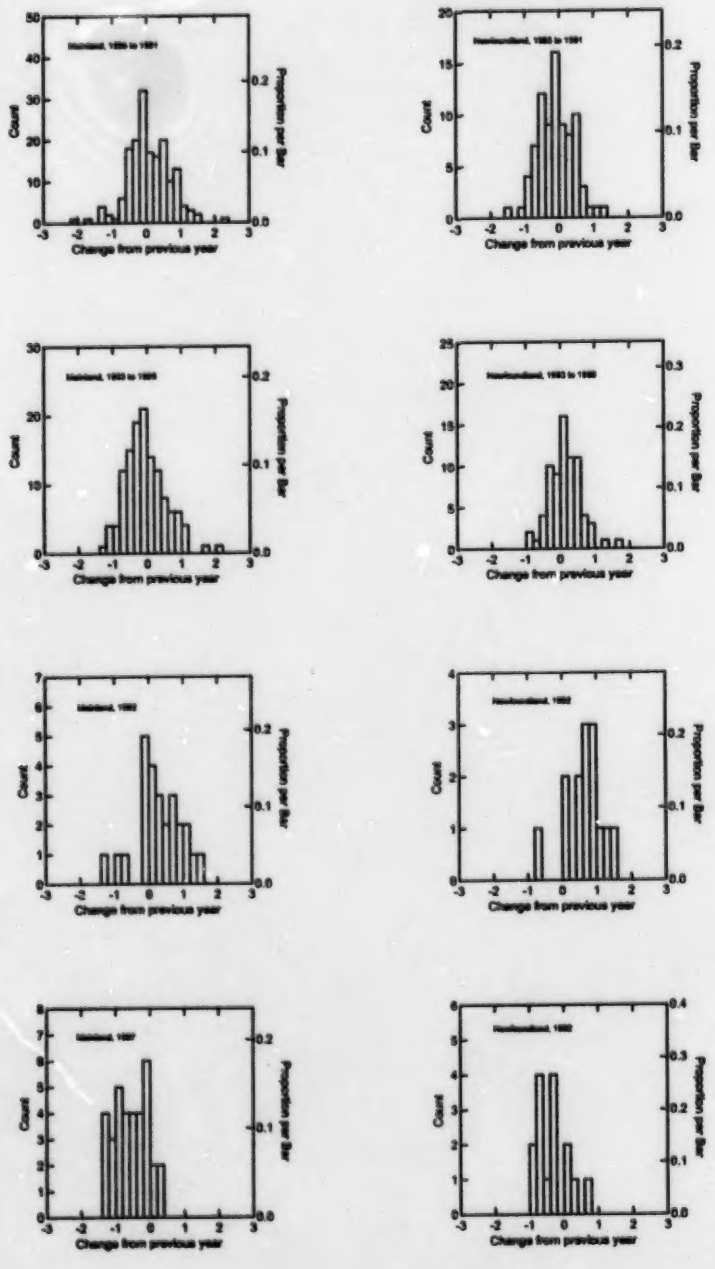


Figure 8. Change from previous year (natural log) in returns of small salmon to mainland Canada rivers (left panels) and Newfoundland rivers (right panel), 1985 to 1997.

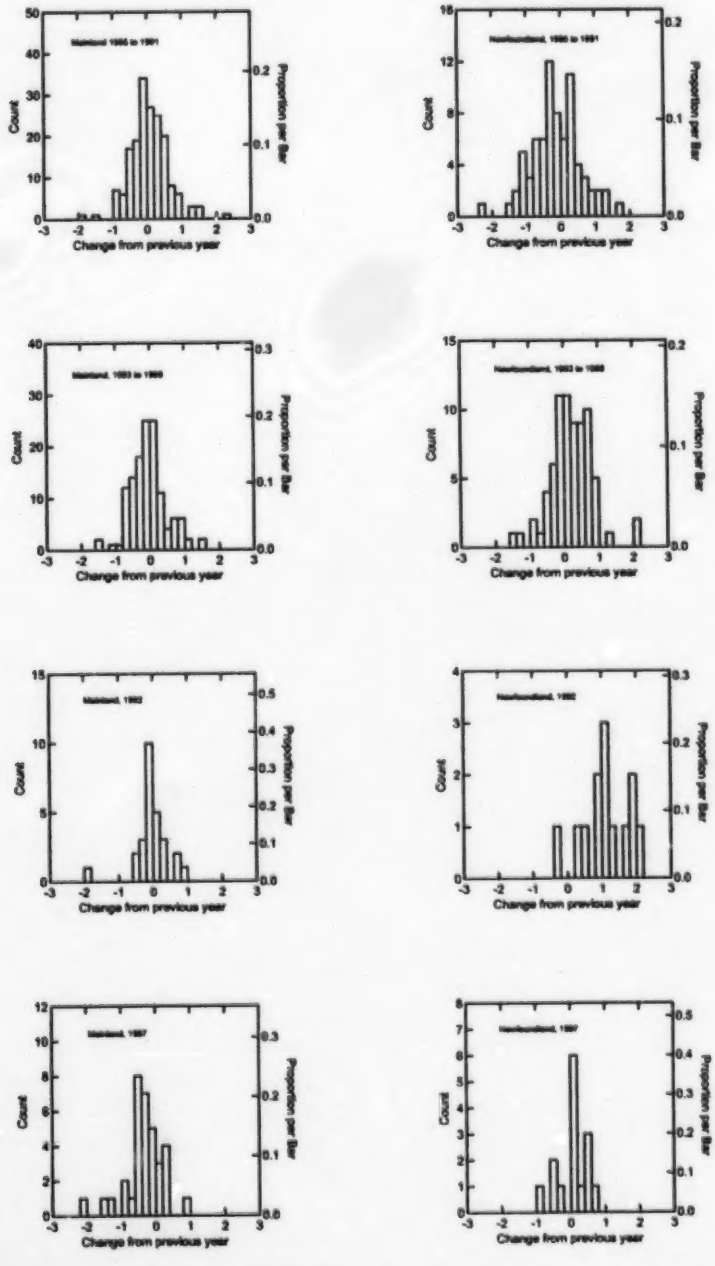
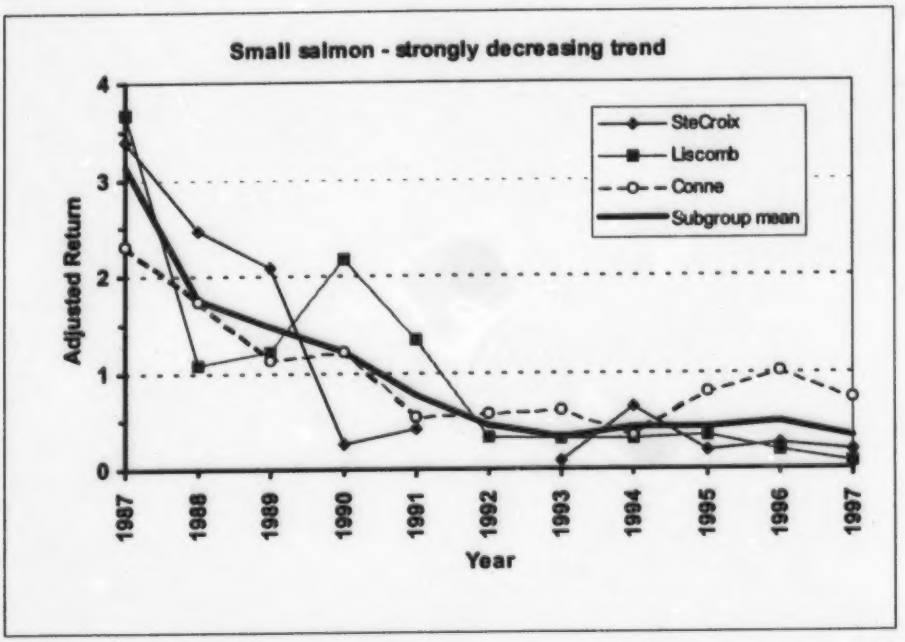


Figure 9. Change from previous year (natural log) in returns of large salmon to mainland Canada rivers (left panels) and Newfoundland rivers (right panel), 1985 to 1997.



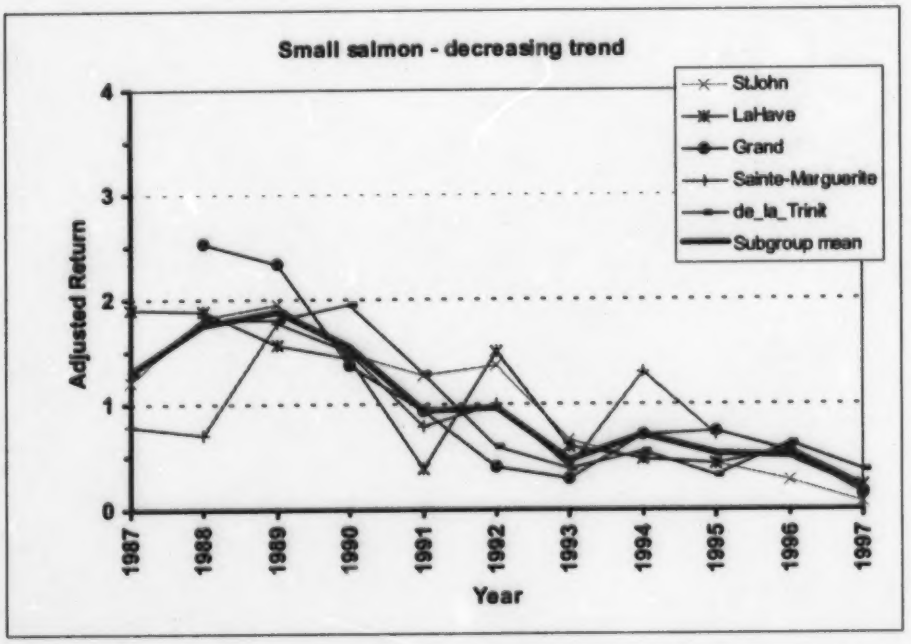
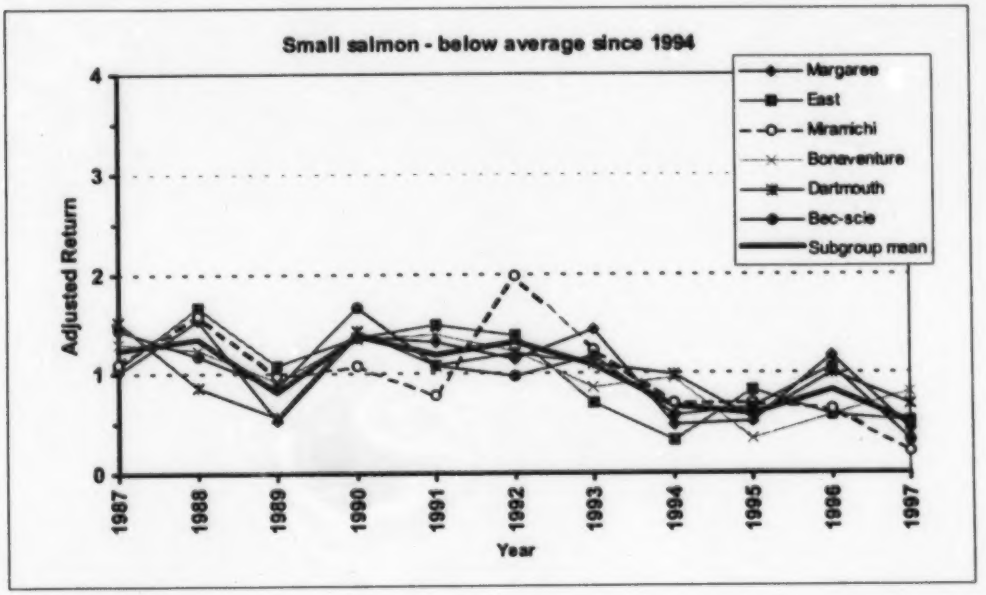


Figure 10. Rivers with small salmon returns to rivers characterized as decreasing between 1987 and 1997 divided in two subgroups according to the strength of the decline.



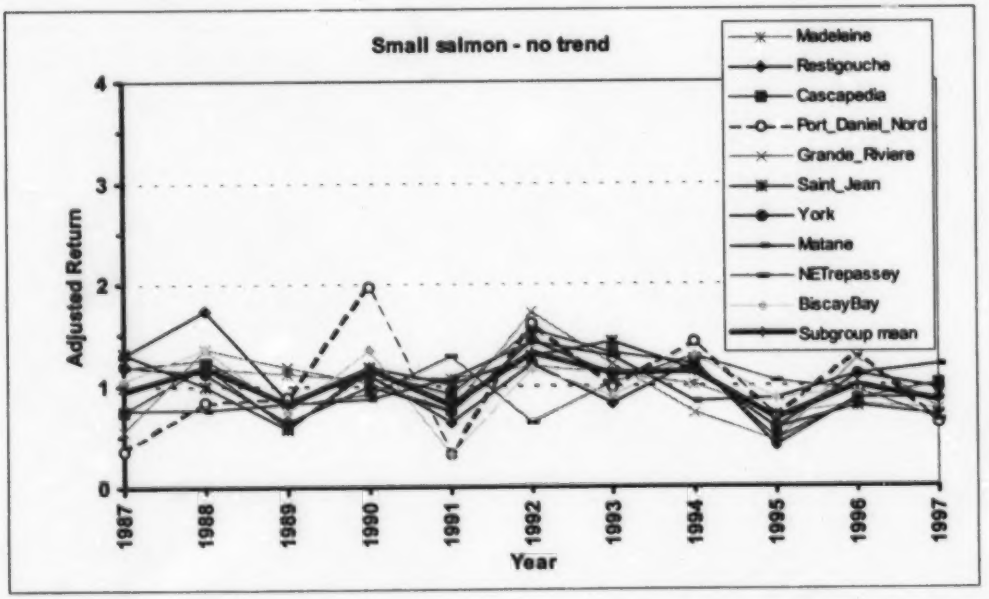


Figure 11. Small salmon returns to rivers characterized as stable or slight decreasing trend between 1987 and 1997.

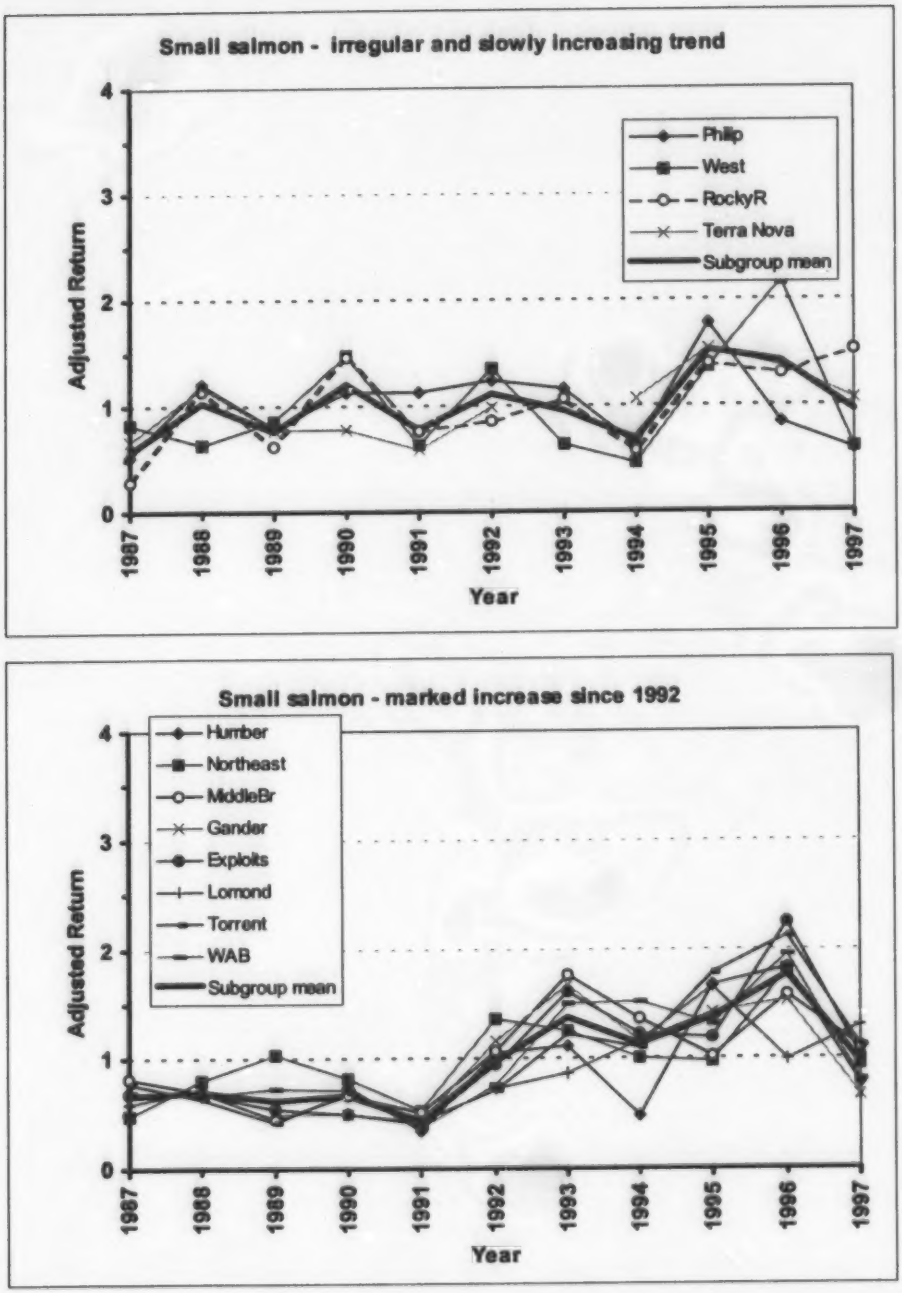


Figure 12. Small salmon returns to rivers characterized by an increasing trend between 1987 and 1997 divided into two subgroups according to the strength of the increase.

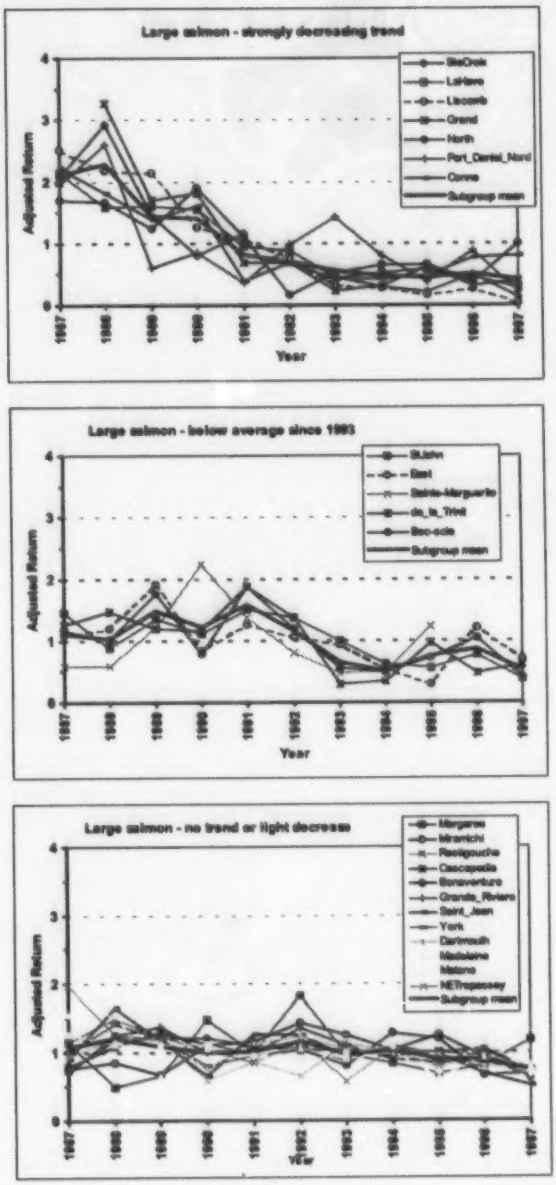
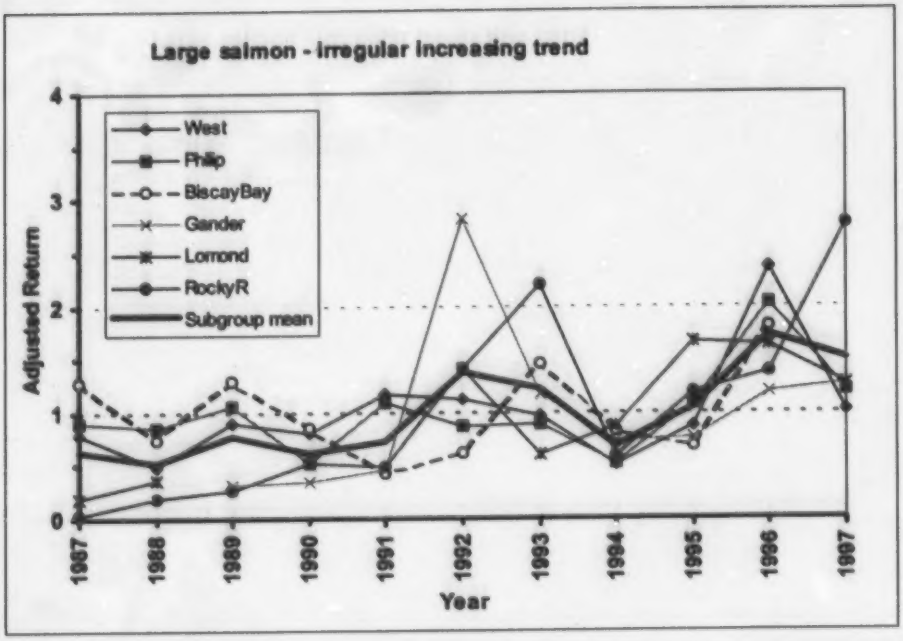


Figure 13. Large salmon returns to rivers characterized by a decreasing trend between 1987 and 1997 divided into three subgroups according to the strength of the decrease.



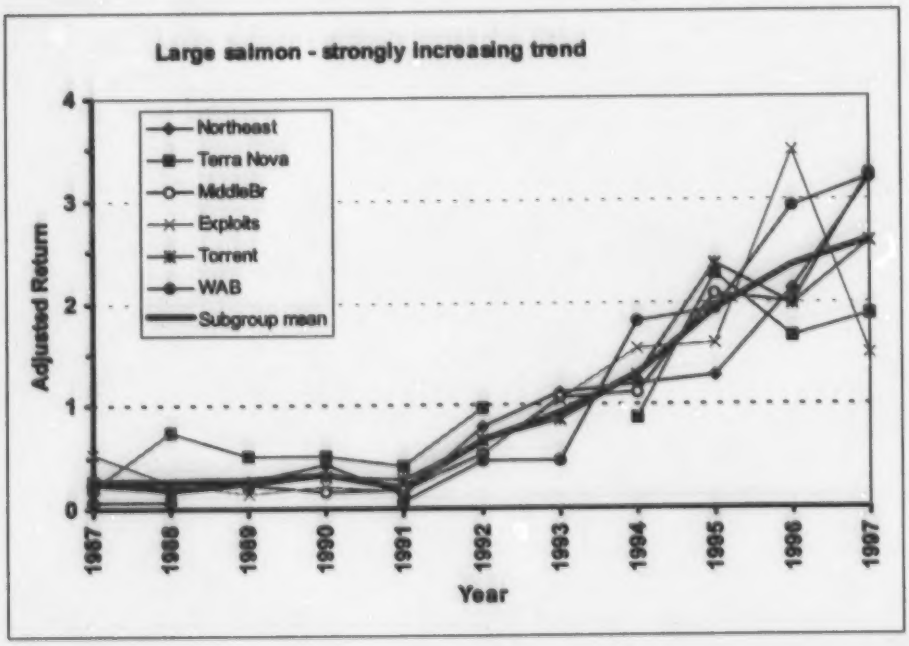


Figure 14. Large salmon returns to rivers characterized by an increasing trend between 1987 and 1997 divided into two subgroups according to the strength of the increase.

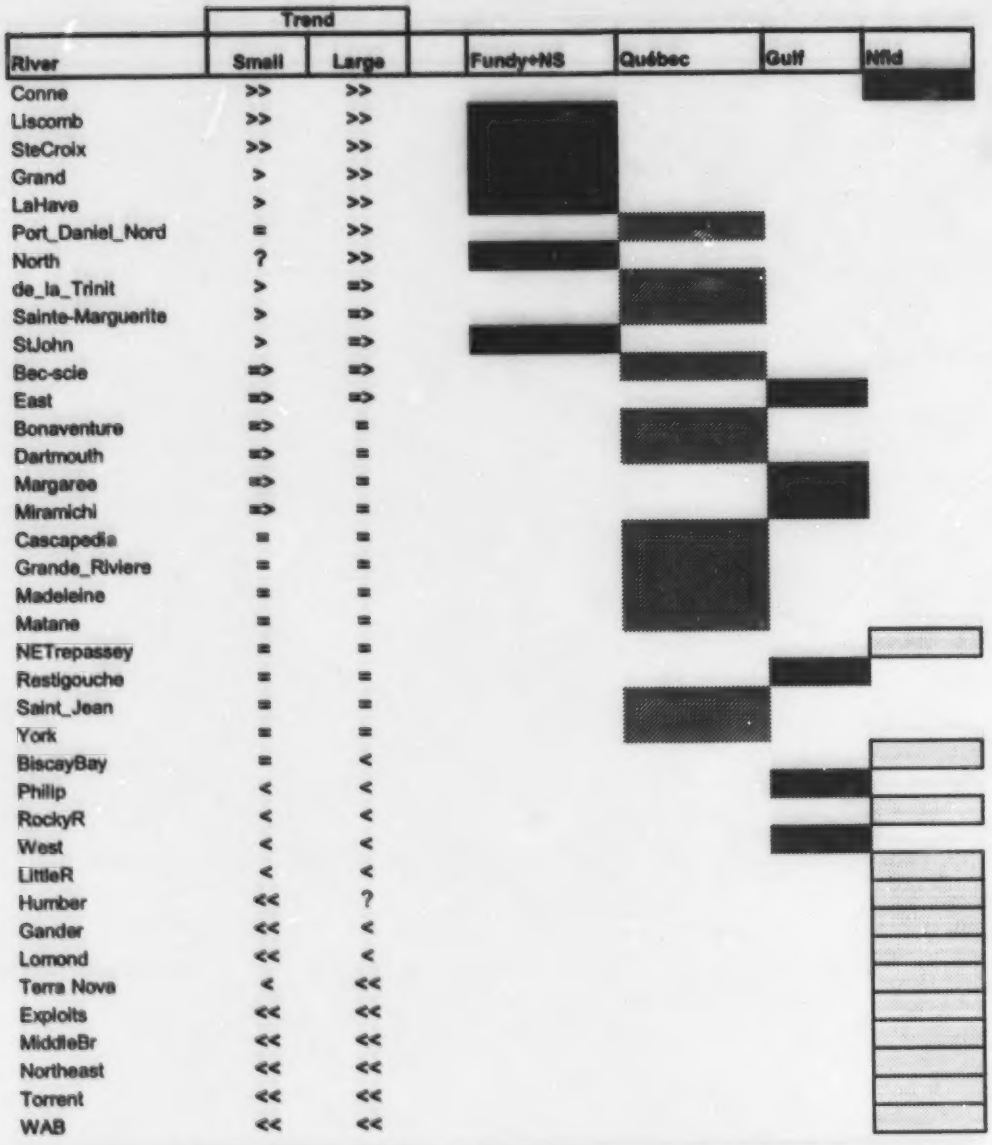


Figure 15. Summary of of patterns in times series of adult returns between 1987 and 1997 for 38 rivers of eastern Canada grouped by region. ">" means declining abundance, "=" means stable abundance, "<" means increasing abundance, "?".means no data.

Appendix 1. At-sea survival (%) based on returns to the river of 1SW salmon (upper) and 2SW salmon (lower) to rivers of eastern Canada, 1970 to 1997.

Survival (%) to 1SW salmon

Year of Smolt Migration	Hatchery stocks				Wild stocks						
	Saint John	Laliberte	Lamontis	Restigouche	de la Trinite	Dickson	Hayle-rock	Campbellton	WAB		
1971											0.7
1972			2.8								0.7
1973			3.1								0.0
1974	1.9		1.8								0.4
1975	2.8		0.8								0.9
1976	2.4		2.6								0.9
1977	1.0		1.0								3.1
1978	2.0		2.1	1.9							12.0
1979	4.4		1.7	1.6							0.8
1980	2.4		2.8	0.9					0.8		3.0
1981	1.8		2.8	2.0					0.8		3.3
1982	0.9		1.1	1.4							0.1
1983	1.0		1.7	0.8							2.2
1984	0.9		2.3	0.4			1.6				2.2
1985	0.9		5.2	2.8			2.4				3.9
1986	1.2		3.7	2.8			1.4				2.5
1987	0.7		5.0	1.4			2.1				2.1
1988	0.8		2.6	0.8		1.8	3.6				3.0
1989	0.4		2.9	1.8		1.7	2.4	0.8			3.9
1990	0.8			0.8	0.2	1.7	2.7	0.6			2.2
1991	0.7		4.8	0.5	0.4	0.8	1.2	1.4	0.5		3.8
1992	0.4		1.3	0.4	0.1	0.5	1.3	0.8	0.4		5.3
1993	0.4		0.8	0.8	0.1	0.4	0.9	0.7	0.4	1.5	0.0
1994	0.7		1.4	0.3	0.0		1.2	0.6	0.3	1.8	7.3
1995	1.2		2.3	0.8	0.1		1.4	0.9	0.8	1.8	0.1
1996	0.8		0.5	0.2	0.2			0.6	0.3	3.2	2.4
1997											3.5

Survival (%) to 2SW Salmon

Year of Smolt Migration	Hatchery stocks				Wild stocks						
	Saint John	Laliberte	Lamontis	Restigouche	de la Trinite	Dickson	Hayle-rock	Campbellton	WAB		
1971											
1972			0.2								
1973			0.4								
1974	0.7		0.2								
1975	0.8		0.3								
1976	0.9		0.5								
1977	0.4		0.2								
1978	1.5		0.5	0.1							
1979	1.1		1.2	0.1							
1980	0.8		0.2	0.2					0.4		
1981	0.6		0.2	0.2							
1982	0.8		1.4	0.1							
1983	0.8		0.5	0.1							
1984	0.3		0.9	0.2			0.8				
1985	0.5		2.1	0.2			0.8				
1986	0.4		0.2	0.2			0.8				
1987	0.3		1.0	0.2			0.5				
1988	0.2		0.4	0.1		1.0	0.9				
1989	0.2		0.2	0.1		1.4	0.8	1.5			
1990	0.3		0.2	0.1	0.4	0.2	1.4	1.1	1.4		
1991	0.1		0.5	0.1	0.1	0.8	0.4	0.8	0.9		
1992	0.2		0.2	0.0	0.1	0.5	0.4	0.5	0.7		
1993	0.2		0.2	0.0	0.2	0.4	0.9	0.7	0.8	1.2	
1994	0.3		0.2	0.0	0.0		1.5	0.7	1.0	1.4	
1995	0.2		0.2	0.0	0.0		0.4	0.5	0.9	1.3	
1996											

Appendix 2. Returns (number of fish) to the river of wild small salmon to rivers of eastern Canada, 1970 to 1997.

Origin: WILD
Size: SMALL

SFA / ZP (Québec)	Outer Fundy / Atlantic Coast of Nova Scotia						Cape Breton	
Type	23 Count	23 Count	23 Count	23 Return	21 Count	20 Count	19 Return	19 Return
Year	Magaguadavic	St. Croix	Nashwaak	Saint John	LaHave	Liscomb	Grand (above falls)	Middle
1970				3087	2			
1971				1700	3			
1972			258	956	8			
1973			596	2070	14			
1974				3886	29			
1975			1223	6858	38			
1976				8147	178			
1977				3977	292			
1978				1902	275			
1979				6828	858	80		
1980				8482	1648	111		
1981				6614	1680	76		
1982		10		5174	804	252		
1983	282	22		4555	1118	520		
1984	255	166		8311	2041	806		
1985	188	41		6626	1348	587		
1986		38		7904	1884	736		
1987		128		8909	2491	1814		
1988	291	93		8830	2465	477	600	
1989		79		9622	2053	532	583	76
1990		10		7263	1866	955	330	213
1991		16		6236	459	566	225	66
1992	155			6883	1950	145	95	84
1993	112	3	72	3213	788	134	68	60
1994	69	24	376	2276	841	134	169	40
1995	49	7	544	2168	577	150	178	55
1996	48	10	854	1326	735	85	130	141
1997	35	7	332	343	303	27	33	69
Reference	2	2	2	2	3	4	6, 7	6, 7

Origin: WILD
Size: SMALL

SFA / ZP (Québec)	Cape Breton			Northumberland Strait				
Type	19 Return	19 Return	18 Return	18 Return	18 Return	18 Return	18 Return	18 Return
Year	Baddeck	North	Margaree	West (Arg.)	Sutherlands	East Pictou	Philip	Buctouche
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978								
1979								
1980								
1981								
1982								
1983								
1984			504					
1985			838	76		98	27	
1986			1098	278		204	250	
1987			1478	190		195	169	
1988			2208	147		303	384	
1989			788	200		198	254	
1990			1977	342		247	362	
1991			1909	148		270	360	
1992			1645	312		251	398	
1993			2087	148		127	373	78
1994	36	138	708	105		80	198	77
1995	96	98	737	315	17	152	588	98
1996	66	243	1685	505	19	105	389	127
1997	58	121	641	140	25	93	188	67
Reference	6, 7	6, 7	7	5, 6	6	5, 6	5, 6	6

Appendix 2 (continued).

Origin	WILD							
Size	SMALL							
	Miramichi						Baie des Chaleurs	
SFA / ZP (Québec)	16	16	16	16	16	16	15	15
Type	Return	Return	Return	Count	Count	Count	Count	Return
		NW	SW	NW				
Year	Miramichi	Miramichi	Miramichi	Baie du Nord	Dungarvon	Juniper	Jacquet	Restigouche
1970								3837
1971	38873							4543
1972	46275							4257
1973	44345							7357
1974	73419							4655
1975	84902							5123
1976	91380							10670
1977	27743							11075
1978	24387							7762
1979	50986							10121
1980	41388							14610
1981	68273				580	671		17103
1982	80379				483	621		13412
1983	25184				330	290		9057
1984	29707				315	230		14389
1985	60690				536	482		13897
1986	117849				501	2072		21027
1987	84816				744	1175		19906
1988	121919			1614	851	1032		26713
1989	75231			986	579	969		13188
1990	83448			1318	562	1046		16885
1991	98889			765	296	486		9795
1992	152647	30321	139701	1185	825	1383		18470
1993	96000	46200	43800	1034	689	1349		12986
1994		29800	33775	973	358	1223	613	16807
1995		22379	31675	948	329	811	358	6177
1996		18943	30841	682	616	1398	600	13231
1997		5800	11000	501	391	946	371	
Reference	10	10	10	10	10	10	11	12

Origin	WILD							
Size	SMALL							
	Baie des Chaleurs				Saint Laurent			
SFA / ZP (Québec)	1	1	2	2	2	2	2	3
Type	Return	Return	Return	Return	Return	Return	Return	Return
			Port Daniel	Grande				
Year	Cascapedia	Bonaventure	Nord	Rivière	Saint Jean	York	Dartmouth	Madeleine
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978								
1979								
1980								
1981								
1982								
1983								
1984	21	163	5	84	113	104	39	130
1985	65	360	8	74	61	132	88	286
1986	106	821	12	85	158	196	121	734
1987	180	1237	18	139	568	467	818	826
1988	256	1173	43	337	430	436	293	731
1989	126	878	45	252	246	248	190	686
1990	243	1291	101	251	511	388	466	851
1991	197	1329	17	188	437	292	388	839
1992	332	1160	83	423	558	586	411	737
1993	264	826	50	299	615	433	372	804
1994	261	918	73	179	494	451	337	624
1995	101	336	35	111	245	223	185	442
1996	183	655	68	309	330	432	340	800
1997	217	771	32	187	304	375	236	466
Reference	23	23	23	23	23	23	23	23

Appendix 2 (continued)

Origin WILD
Size SMALL

SFA / ZP (Québec)	Saint-Laurent					Anticosti		
Type	3 Return	6 Return	6 Return	7 Return	8 Return	10 Return	10 Return	10 Return
Year	Matane	Sainte-Marguerite (nord-est)	Sainte-Marguerite (principale)	de la Trinité	Moisie	Baie aux	de la Chaloupe	Jupiter
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978								
1979								
1980								
1981								
1982								
1983								
1984	998	122		1808				
1985	794	379		1107				
1986	2236	311		1803				
1987	1081	286		1362		125		
1988	1081	258		1896		102		
1989	1171	841		1892		74		
1990	1227	539		2047		144		
1991	1508	286		1349		94		
1992	2014	358		827		84		
1993	1830	148		458		102		
1994	1186	471		579		50		
1995	1239	254		346		57		
1996	1571			983		92	607	1046
1997	1685			394		28	347	397
Reference	23	23		23		23	23	23

Origin WILD
Size SMALL

SFA / ZP (Québec)	Southwest Newfoundland				South coast Newfoundland			
Type	13 Return	13 ?	13 Count	13 Return	11 Return	11 Count	10 Return	10 Count
Year	Highlands	Flatbay	Pinchgut	Humber	Conne	Little R.	Northeast	Northeast
1970								
1971								
1972								
1973								223
1974								
1975								294
1976								
1977								380
1978								454
1979								433
1980	82							334
1981	127							86
1982	100							233
1983								419
1984							459	384
1985							519	725
1986					8302		879	325
1987					10155	84	350	543
1988					7627	65	637	708
1989					4968	102	809	551
1990				12216	5388	158	699	353
1991				5724	2411	55	368	921
1992			222	17571	2523	104	956	847
1993	137		576	18477	2703	169	980	677
1994	145	423	563	7895	1533	73	710	663
1995	172	851	752	27898	3502	118	774	1225
1996	199	1253	601	30445	4440	674	1420	641
1997	398		613		3260			
Reference	13	13	21	13	14	20	15	13

Appendix 2 (continued).

Origin	WILD							
Size	SMALL							
	South coast Newfoundland				Northeast Newfoundland			
SFA / ZP (Quebec)	9	9	9	9	5	5	5	5
Type	Count	Return	Return	Count	Return	Count	Return	Count
Year	Rocky R.	Northeast Trepassey	BisceyBay	BisceyBay	TerraNova	Terra Nova	Middle Br.	Middle Br.
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977						810		1403
1978						589		
1979						843		1712
1980						1115		2414
1981						963		1281
1982				2330		1210		1195
1983				2430	1534	1233	1675	1379
1984		89	2430	1685	2012	1557	1283	904
1985		124	1826	2516	1459	1051	1547	1036
1986		152	2688	1302	1404	974	1053	914
1987	80	91	1383	1685	2114	1737	1337	772
1988	313	97	1802	912	1377	1138	626	496
1989	188	62	1004	1657	1518	1149	1070	745
1990	491	71	1670	394	1127	873	763	582
1991	211	99	394	1442	1780	1443	1563	1182
1992	237	49	1467	1107	3080		2247	1859
1993	292	79	1117	1582	3038	1571	1844	1513
1994	158	99	1600	1071	2838	2258	1448	1139
1995	385	80	1151	1182	2575	2095	2112	1751
1996	356	73	1217			1577		1221
1997	420	50						
Reference	20	13	15	13	15	13	15	13

Origin	WILD							
Size	SMALL							
						Northern Peninsula, Labrador		
SFA / ZP (Quebec)	4	4	4	4	4	14	14	14
Type	Return	Count	Return	Count	Count	Return	Count	Return
Year	Gander	Salmon Br.	Campbellton	Exploits R. Nuhgo Falls	Rattling Br.	Lomond	Lomond	Torrent
1970								
1971						60	6	107
1972						283	30	86
1973						394	108	184
1974		857		2539		385	41	96
1975				9218	5531	259	1	314
1976				3991	2935	782	132	341
1977				6148	4300	667	182	789
1978		755		3790	2704	462	117	1002
1979				6715	3825	430	195	2049
1980		997			4597	584	301	782
1981		2459		9114	4264	617	110	2268
1982		1425		7605	2798	583	275	2299
1983		978				471	220	2089
1984		1081		17219		988	440	1805
1985		1653		16652	9966	393	190	1623
1986		1064		9897	3072	725	354	3155
1987		493		9014	2327	652	355	2670
1988		1562		8874	3433	841	437	2388
1989	7743	896		7192	1894			1512
1990	7740	345		8629	1057			2518
1991	6745	245		5245	1080			1891
1992	18179	1188		12538	3620	794	435	2832
1993	26205	1580	4001	21319		818	526	4215
1994	16373	988	2857	16186		1038	701	3827
1995	22368	1600	3035	15714		1388	1003	6188
1996	23946	948	3208	29761		982	601	7371
1997	10487	488	1975	13552		1091	783	3659
Reference	16	16	13	13	13	17, 22	22	22

Appendix 2 (continued).

Origin	WILD			
Size	SMALL			
SFA / ZP (Québec)	14	14	14B	2
Type	Count	Return	Return	Return
		Western		
Year	Torrent	Arm Brook	Forteau	Sandhill
1970				3000
1971	54	632		3596
1972	64	406		2038
1973	96	797		4761
1974	38	506		
1975	191	639		
1976	341	552		
1977	789	373		
1978	971	316		
1979	1984	1578		
1980	792	485		
1981	2101	492		
1982	2112	467		
1983	2097	1141		
1984	1666	235		
1985	1853	467		
1986	2815	527		
1987	2506	437		
1988	2075	422		
1989	1389	455		
1990	2298	444		
1991	1441	233		
1992	2347	480		
1993	4009	947		
1994	3592	954	458	2180
1995	5800	823	461	2796
1996	6923	1230		3319
1997	3688	909		
Reference	13, 22	13, 22	16	19

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Appendix 3. Returns (number of fish) to the river of wild large salmon to rivers of eastern Canada, 1970 to 1997.

Origin: WILD Size: LARGE								
	Outer Fundy / Atlantic Coast of Nova Scotia						Cape Breton	
SFA / ZP (Québec) Type	23 Count	23 Count	23 Count	23 Return	21 Count	20 Count	19 Return	19 Return
Year	Magaguadavic	St. Croix	Nashwaak	Saint John	LaHave	Liscomb	Grand (above falls)	Middle
1970				5712	4			
1971				4715				
1972			809	4890	2			
1973			1956	2518	7			
1974				5811	2			
1975			1030	7441	5			
1976				8177	23			
1977				9712	25			
1978				4021	67			
1979				2754	67			
1980				10924	294			
1981				5766	349	6		
1982		51		5528	257	10		
1983	807	78		5783	217	15		
1984	512	64		9779	382	48		
1985	466	264		10436	629	87		
1986		254		6128	589	117		
1987		135		4352	524	88		
1988	398	190		2625	388	76	85	
1989		94		4072	392	75	44	1070
1990		52		3329	382	44	47	819
1991		75		4491	233	38	18	464
1992	139			4104	217	27	18	409
1993	125	30	113	2958	110	11	6	94
1994	61	19	251	1844	128	10	8	430
1995	30	14	294	1654	143	6	16	324
1996	21	32	381	2309	112	9	8	458
1997	24	9	339	1123	68	1	10	383
Reference	2	2	2	2	3	4	6, 7	6, 7

Origin: WILD Size: LARGE								
	Cape Breton			Northumberland Strait				
SFA / ZP (Québec) Type	19 Return	19 Return	19 Return	18 Return	18 Return	18 Return	18 Return	18 Return
Year	Baddeck	North	Margaree	West (Arm.)	Sutherlands	East Pictou	Philip	Bactouche
1970								
1971								
1972								
1973								
1974		995						
1975		877						
1976		936						
1977		876						
1978		1042						
1979		896						
1980		880						
1981		301						
1982		819						
1983		576						
1984		336	412					
1985		852	1462	174		224	97	
1986		2020	3816	849		855	485	
1987		1062	4C15	279		540	477	
1988		1070	1688	175		585	458	
1989		800	2299	316		842	566	
1990		1220	5158	284		407	279	
1991		710	3484	414		619	578	
1992		110	6375	398		523	461	
1993		339	3358	339		456	474	96
1994	186	422	2900	181		265	281	225
1995	265	416	2386	307	24	141	572	154
1996	263	243	2782	832	59	592	1077	134
1997	175	637	4091	359	48	345	840	191
Reference	6, 7	6, 7	7	5, 6	6	5, 6	5, 6	9

Appendix 3 (continued).

Origin	WILD							
Size	LARGE							
	Miramichi						Baie des Chaleurs	
SFA / ZP (Québec)	16	16	16	16	16	16	15	15
Type	Return	Return	Return	Count	Count	Count	Count	Return
Year	Miramichi	NW Miramichi	SW Miramichi	NW Barrier	Dungarvon	Juniper	Jacquet	Restigouche
1970								26264
1971	24407							12999
1972	29049							20027
1973	27192							19708
1974	42582							23672
1975	28817							12670
1976	22801							23732
1977	51842							29734
1978	24493							20226
1979	9064							8802
1980	36318							28289
1981	16182				112	84		20570
1982	30758				122	282		16380
1983	27924				126	219		14251
1984	15137				93	297		12341
1985	20738				182	604		18733
1986	31285				174	1138		26112
1987	19421				202	1266		18462
1988	21745			234	277	929		23951
1989	17211			287	315	731		19915
1990	28574			331	318	994		16428
1991	29949			224	204	476		13560
1992	37080	10000	25029	219	232	1047		18804
1993		10541	21900	216	223	1145		9348
1994		12600	14000	228	153	877	595	17123
1995		15227	17087	252	95	1019	584	12243
1996		7957	15734	218	188	819	337	16317
1997		5700	10500	152	115	519	282	
Reference	10	10	10	10	10	10	11	12

Origin	WILD							
Size	LARGE							
	Baie des Chaleurs				Saint-Laurent			
SFA / ZP (Québec)	1	1	2	2	2	2	2	3
Type	Return	Return	Return	Return	Return	Return	Return	Return
Year	Cascapedia	Bonaventure	Port Daniel Nord	Grande Rivière	Saint Jean	York	Dartmouth	Madeleine
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978								
1979								
1980								
1981								
1982								
1983								
1984	1378	1517	17	455	1116	1290	669	709
1985	1283	858	13	729	795	903	458	614
1986	1868	1901	29	446	819	1068	602	836
1987	1946	1588	273	472	1066	1551	961	1286
1988	2859	2610	366	838	1943	2150	1248	1137
1989	3186	2947	85	914	1391	1845	1214	1127
1990	2752	2633	119	867	774	1230	788	1134
1991	2368	2368	51	855	1487	1453	1169	957
1992	2507	2294	138	910	1479	1855	1252	890
1993	2565	1770	200	743	1108	1320	1069	979
1994	2311	2800	112	692	1258	1582	1071	1111
1995	2452	2609	53	564	1138	1515	1001	740
1996	2552	1440	125	567	802	1440	811	1144
1997	1784	1493	30	477	598	1137	769	692
Reference	23	23	23	23	23	23	23	23

Appendix 3 (continued).

Origin	WILD							
Size	LARGE							
	Saint-Laurent					Anticosti		
SFA / ZP (Québec)	3	6	6	7	8	10	10	10
Type	Return	Return	Return	Return	Return	Return	Return	Return
Year	Matane	Sainte-Marguerite (nord-est)	Sainte-Marguerite (principale)	de la Trinité	Moisie	Bec scie	de la Chaloupe	Jupiter
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978								
1979								
1980								
1981								
1982								
1983								
1984	1201	177		1018				
1985	1297	26		1236				
1986	1631	126		1227				
1987	2330	265		1144		80		
1988	2318	262		1336		70		
1989	976	550		1079		122		
1990	1580	997		1065		54		
1991	1450	612		1707		130		
1992	1579	355		1255		83		
1993	1338	209		272		38		
1994	1490	229		328		34		
1995	938	545		871		50		
1996	1381			434		72	468	883
1997	1191			554		28	529	871
Reference	23	23		23		23	23	23

Origin	WILD							
Size	LARGE							
	Southwest Newfoundland				South coast Newfoundland			
SFA / ZP (Québec)	13	13	13	13	11	11	10	10
Type	Return	?	Count	Return	Return	Count	Return	Count
Year	Highlands	Flatbay	Pinchgut	Humber	Conne	Little R.	Northeast	Northeast
1970								
1971								
1972								
1973								9
1974								
1975								58
1976								
1977								32
1978								37
1979								34
1980	55							62
1981	29							36
1982	56							22
1983							44	44
1984							0	0
1985					412		39	39
1986					516	3	16	16
1987					420	3	11	11
1988					320	5	15	15
1989				855	372	15	25	25
1990				401	89	6	8	8
1991			5	2945	159	21	48	48
1992			43	636	100	11	65	65
1993	78		47	1030	100	11	70	70
1994	148	67	28	2064	110	17	74	74
1995	120	47	38	2679	179	127	123	123
1996	142	112	88		185		195	185
1997	157							
Reference	13	13	21	13	14	20	15	13

Appendix 3 (continued).

Origin	WILD							
Size	LARGE							
	South coast Newfoundland				Northeast Newfoundland			
SFA / ZP (Québec)	9	9	9	9	5	5	5	5
Type	Count	Return	Return	Count	Return	Count	Return	Count
Year	Rocky R.	Northeast Trepassey	BiscayBay	BiscayBay	Terrallova	Terra Nova	Middle Br.	Middle Br.
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978						20		16
1979						170		
1980						39		91
1981						90		39
1982						19		20
1983				88		57		75
1984		33	93	93	107	107	57	57
1985		41	25	25	112	112	27	27
1986		30	101	101	140	140	15	15
1987	1	30	106	106	56	56	19	19
1988	6	19	61	61	206	206	14	14
1989	9	18	107	107	142	142	19	19
1990	17	9	73	71	144	144	13	13
1991	16	13	35	35	114	114	14	14
1992	48	10	51	51	270	270	43	43
1993	72	17	120	120			88	87
1994	19	15	68	68	246	242	90	90
1995	39	12	56	56	638	634	188	188
1996	45	15	149	149	472	464	161	161
1997	91	9				527	262	262
Reference	20	13	15	13	15	13	15	13

Origin	WILD							
Size	LARGE							
						Northern Peninsula, Labrador		
SFA / ZP (Québec)	4	4	4	4	4	14	14	14
Type	Return	Count	Return	Count	Count	Return	Count	Return
Year	Gander	Salmon Br.	Campbellton	Exploits R. Bishops Falls	Rattling Br.	Lomond	Lomond	Torrent
1970								
1971						1	0	9
1972						50	15	6
1973						185	110	15
1974		9		411		52	33	7
1975				1439	505	20	0	31
1976				460	117	36	11	47
1977				581	271	45	11	33
1978		52		303	81	41	12	25
1979				277	124	3	1	42
1980		15			426	32	19	83
1981		33		1895	514	53	50	115
1982		19		181	122	23	16	525
1983		12				10	7	443
1984		38		529		75	47	289
1985		26		183	38	14	14	30
1986		12		355	174	37	32	93
1987		9		310	41	12	11	68
1988		24		147	10	24	21	44
1989	473	24		89	14			80
1990	508	8		122	15			82
1991	670	2		98	40			71
1992	4180	101		314	242	86	80	170
1993	1734	87	145	627		38	34	224
1994	1072	83	191	916		58	50	332
1995	1121	125	218	941		101	95	615
1996	1753	112	580	2053		99	93	509
1997	1871	119	321	886		76	72	666
Reference	16	16	13	15	13	17, 22	22	22

Appendix 3 (continued).

Origin	WILD			
Size	LARGE			
SFA / ZP (Québec)	14	14	14B	2
Type	Count	Return	Return	Return
Year	Torrent	Western Arm Brook	Forteau	Sandhill
1970				138
1971	4	308 *		266
1972	3	9		175
1973	12	30		504
1974	3	4		
1975	25	1		
1976	47	0		
1977	33	3		
1978	21	2		
1979	39	0		
1980	63	5		
1981	97	1		
1982	523	3		
1983	442	4		
1984	288	0		
1985	30	1		
1986	92	0		
1987	68	1		
1988	44	1		
1989	60	0		
1990	82	0		
1991	71	1		
1992	189	8		
1993	222	8		
1994	331	31	77	730
1995	611	33	147	560
1996	507	50		414
1997	886	85		
Reference	13, 22	13, 22	18	19

* suspected miscount on WAB large 1971

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Appendix 4. Returns (number of fish) to the river of wild small salmon and large salmon to rivers of eastern Canada, 1970 to 1997.

Origin	WILD							
Size	Small & Large							
	Outer Fundy / Atlantic Coast of Nova Scotia						Cape Breton	
SFA / ZP (Québec)	23	23	23	23	21	20	19	19
Type	Count	Count	Count	Return	Count	Count	Return	Return
Year	Magaguadavic	St. Croix	Nashwaak	Saint John	LaHave	Lincoln	Grand (above falls)	Middle
1970				21	6			
1971				31	3			
1972			1118	5807	10			
1973			2552	4580	21			
1974				9467	31			
1975			2299	14298	43			
1976				16324	201			
1977				13889	317			
1978				5823	342			
1979				9582	923	80		
1980				19406	1942	111		
1981				12390	2229	82		
1982		61		10702	1061	282		
1983	899	100		10338	1335	535		
1984	767	230		18090	2433	654		
1985	635	305		16962	1977	594		
1986		242		14032	2173	853		
1987		283		10261	3015	1702		
1988	669	283		11555	2953	553	884	
1989		173		13594	2445	607	607	1148
1990		62		10682	2248	999	377	732
1991		91		10747	732	624	243	519
1992	294			10787	2167	172	113	463
1993	237	33	185	6171	868	145	74	184
1994	130	43	627	4120	769	144	177	470
1995	79	21	838	3822	720	156	194	379
1996	69	42	1245	3635	847	94	138	599
1997	59	15	671	1486	371	29	43	422
Reference	2	2	2	2	3	4	8, 7	8, 7

Origin	WILD							
Size	Small & Large							
	Cape Breton			Northumberland Strait				
SFA / ZP (Québec)	19	19	18	18	18	18	18	16
Type	Return	Return	Return	Return	Return	Return	Return	Return
Year	Baddeck	North	Margaree	West (Ant.)	Sutherlands	East Pictou	Philip	Buctouche
1970								
1971								
1972								
1973								
1974		985						
1975		677						
1976		836						
1977		876						
1978		1042						
1979		596						
1980		850						
1981		301						
1982		819						
1983		576						
1984		336	916					
1985		852	2300	250		312	124	
1986		2020	4712	927		1050	715	
1987		1092	5493	469		735	646	
1988		1070	3897	322		868	842	
1989		800	3057	516		1138	820	
1990		1220	7133	626		654	841	
1991		710	5393	560		889	938	
1992		110	6020	710		774	859	
1993		339	5445	487		583	847	173
1994	231	560	3608	286		325	479	302
1995	361	517	3102	622	41	293	1140	252
1996	329	486	4477	1337	78	697	1346	261
1997	233	758	4732	499	71	438	828	258
Reference	8, 7	8, 7	7	5, 6	6	5, 6	5, 6	9

Appendix 4 (continued).

Origin: WILD
Size: Small & Large

SFA / ZP (Québec)		Miramichi			Baie des Chaleurs			
Type		16 Return	16 Return	16 Return	16 Count	16 Count	16 Count	15 Count	15 Return
Year		Miramichi	NW Miramichi	SW Miramichi	NW Bartibog	Dungarvon	Juniper	Jacquet	Restigouche
1970									32121
1971		66880							17542
1972		75324							24294
1973		71737							27085
1974		116010							28327
1975		83719							17793
1976		114381							39402
1977		79585							41709
1978		48780							27980
1979		60019							18823
1980		77806							40879
1981		81455				882	725		37763
1982		111137				605	903		29772
1983		53108				456	509		19309
1984		44844				408	527		20810
1985		81538				886	1096		32730
1986		148834				675	3210		47139
1987		104237				946	2441		38388
1988		143684			1848	1128	2021		50884
1989		82442			1253	894	1700		33101
1990		112022			1649	880	2640		33323
1991		90818			989	500	971		23365
1992		188647	40321	145729	1384	1057	2430		37184
1993			58741	84500	1250	882	2494		22015
1994			33200	47775	901	511	2100	1208	35930
1995			37606	48772	800	424	1930	943	18420
1996			26900	45975	820	904	2207	937	29548
1997			11300	21500	653	508	1085	653	
Reference		10	10	10	10	10	10	11	12

Origin: WILD
Size: Small & Large

SFA / ZP (Québec)		Baie des Chaleurs				Gaspé-Laurent			
Type		1 Return	1 Return	2 Return	2 Return	2 Return	2 Return	2 Return	3 Return
Year		Cascapedia	Bonaventure	Port Daniel Nord	Grande Rivière	Saint Jean	York	Dartmouth	Madeleine
1970									
1971									
1972									
1973									
1974									
1975									
1976									
1977									
1978									
1979									
1980									
1981									
1982									
1983									
1984		1399	1680	22	519	1229	1394	709	839
1985		1346	1226	19	803	868	1035	557	900
1986		1972	2722	41	531	974	1262	723	1570
1987		2106	2825	292	811	1632	2018	1479	1892
1988		2915	3783	409	1175	2373	2588	1541	1868
1989		3312	3525	130	1206	1637	2083	1404	1813
1990		2986	3824	220	919	1285	1618	1273	1785
1991		2585	3697	68	843	1824	1745	1538	1616
1992		2839	3444	221	1333	2037	2221	1883	1827
1993		2949	2586	250	1042	1721	1753	1441	1673
1994		2572	3718	185	781	1752	2043	1408	1735
1995		2553	2945	88	675	1383	1731	1186	1182
1996		2735	1995	193	876	1138	1872	1151	1844
1997		2001	2264	62	864	902	1512	1025	1158
Reference		23	23	23	23	23	23	23	23

Appendix 4 (continued).

Origin	WILD							
Size	Small & Large							
	Saint-Laurent					Appalaches		
SFA / ZP (Québec)	3	6	6	7	8	10	10	10
Type	Return	Return	Return	Return	Return	Return	Return	Return
Year	Matane	Sainte-Marguerite (nord-est)	(principale)	de la Trinité	Moisie	Bec-scie	de la Chaloupe	Jupiter
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978								
1979								
1980								
1981								
1982								
1983								
1984	2089	299	682	2239		172	1480	2264
1985	2091	405	1017	1882		263	681	1994
1986	3867	437	1203	2210		137	1134	1576
1987	3411	551	1067	1962		205	869	1099
1988	3390	520	853	2452		172	1086	1471
1989	2147	1191	769	2306		196	353	1438
1990	2807	1536	1162	2435		198	434	1098
1991	2958	898	924	1850		224	286	1316
1992	3583	713	773	1189		167	272	805
1993	3168	357	394	681	6034	140	373	813
1994	2676	700	409	868	4701	84	882	1110
1995	2177	799	728	1019	5980	107	778	1476
1996	2952	429	446	1068	5495	184	1095	1629
1997	2976	311	496	948		58	876	960
Reference	23	23	23	23	23	23	23	23

Origin	WILD							
Size	Small & Large							
	Southwest Newfoundland				South coast Newfoundland			
SFA / ZP (Québec)	13	13	13	13	11	11	10	10
Type	Return	?	Count	Return	Return	Count	Return	Count
Year	Highlands	FlatBay	Pinchgut	Humber	Conne	Little R.	Northeast	Northeast
1970								
1971								
1972								
1973								232
1974								
1975								350
1976								
1977								422
1978								491
1979								467
1980	137							386
1981	156							122
1982	196							255
1983								463
1984							503	384
1985							519	764
1986					8714		918	341
1987					10671	67	388	554
1988					8047	68	648	721
1989					5288	107	824	576
1990				13071	5740	173	724	361
1991				6125	2500	61	378	967
1992			227	20516	2682	125	1002	912
1993	215		619	19113	2803	180	1045	747
1994	293	490	610	9825	1633	84	780	737
1995	291	609	780	29962	3612	135	848	1348
1996	341	647	639	33124	4819		1543	826
1997	555		681		3385		185	
Reference	13	13	21	13	14	20	15	13

Appendix 4 (continued).

Origin	WILD							
Size	Small & Large							
	South coast Newfoundland				Northeast Newfoundland			
SFA / ZP (Québec)	9	9	9	9	5	5	5	5
Type	Count	Return	Return	Count	Return	Count	Return	Count
Year	Rocky R.	Northeast Trepassey	BlaceyBay	BlaceyBay	TerraNova	Terra Nova	Middle Br.	Middle Br.
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978						830		1419
1979						738		
1980						882		1603
1981						1295		2483
1982						982		1301
1983				2418		1267		1270
1984		122	2513	2513	1641	1340	1732	1436
1985		185	1951	1680	2124	1089	1310	831
1986		189	2789	2617	1599	1191	1562	1051
1987	81	121	1499	1499	1460	1030	1072	933
1988	319	116	1863	1788	2330	1943	1361	786
1989	177	80	1111	1019	1519	1280	845	815
1990	418	80	1743	1728	1662	1293	1063	758
1991	227	112	429	429	1241	987	777	576
1992	283	59	1518	1493	2050	1713	1606	1225
1993	364	86	1237	1227	3080		2335	2046
1994	177	114	1688	1680	2281	1813	1834	1603
1995	424	82	1207	1127	3276	2682	1616	1307
1996	401	88	1386	1331	3047	2469	2273	1912
1997	511	59				2104	262	1483
Reference	20	13	15	13	15	13	15	13

Origin	WILD							
Size	Small & Large							
						Northern Peninsula, Labrador		
SFA / ZP (Québec)	4	4	4	4	4	14	14	14
Type	Return	Count	Return	Count	Count	Return	Count	Return
Year	Gander	Salmon Br.	Campbellton	Exploits R. Bishops Falls	Rattling Br.	Lomond	Lomond	Torrent
1970								
1971						61	6	116
1972						333	45	92
1973						559	218	199
1974		866		2949		417	74	103
1975				10687	8036	279	1	345
1976				4451	3062	818	143	380
1977				6729	4571	732	203	822
1978		807		4083	2785	503	129	1027
1979				6882	4049	433	196	2091
1980		1012			5023	626	330	855
1981		2492			4778	970	160	2383
1982		1443			2918	606	291	2824
1983		980				481	227	2532
1984		1119		17749		1061	487	2083
1985		1880		16835	6023	407	204	1653
1986		1076		10062	3246	762	386	3248
1987		902		9324	2368	864	386	2730
1988		1586		9121	3443	865	418	2432
1989	8216	629		7281	1708			1572
1990	8248	353		6751	1072			2600
1991	7415	247		5344	1100			1662
1992	22380	1260		12852	3762	880	515	3001
1993	27930	1647	4146	21946		954	560	4438
1994	19345	1051	3048	17084		1083	751	4158
1995	23387	1725	3253	16632		1486	1098	6783
1996	25689	1958	3768	31779		1080	894	7890
1997	12338	584	2296	14438		1157	865	4325
Reference	16	16	13	13	13	17, 22	22	22

Appendix 4 (continued).

Origin	WILD			
Size	Small & Large			
SFA / ZP (Québec)	14	14	14B	2
Type	Count	Return	Return	Return
Year	Torrent	Western Arm Brook	Ferteau	Sandhill
1970				3730
1971	58	937		3862
1972	67	415		2213
1973	108	827		5265
1974	41	510		
1975	216	640		
1976	388	882		
1977	822	376		
1978	992	317		
1979	2023	1578		
1980	855	470		
1981	2188	493		
1982	2635	470		
1983	2449	1145		
1984	2083	235		
1985	1583	468		
1986	2907	827		
1987	2573	438		
1988	2119	423		
1989	1429	455		
1990	2378	444		
1991	1512	234		
1992	2516	488		
1993	4231	955		
1994	3923	985	535	2889
1995	6411	858	808	3340
1996	7430	1280		
1997	4325	564		
Reference	13, 22	13, 22	18	19

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